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U. S.
TERTIARY GEOLOGY

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J. C. Branner

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CONTRIBUTIONS

TO THE

Tertiary Geology and Paleontology

OF THE

UNITED STATES.

BY

ANGELO HEILPRIN,

Professor of Invertebrate Paleontology at, and Curator-in-Charge of, the Academy of Natural Sciences of Philadelphia;
Member of the American Philosophical Society, etc.

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THE great number and the fugitive character of the papers treating of the Tertiary Geology of the eastern United States have, in their tendency to cause perplexity to the geological student, been the principal incentive to the publication of the following pages, which are presented to the scientific public in the hope that they may contribute something substantial, even if little, to the physical history of the American domain. The author believes that they embody for the first time a succinct statement of the Tertiary Geology of each of the several States of the Atlantic and Gulf borders in which the formation has been recognized, together with a general systematic review and analysis of the formation taken as a whole. Doubtless, more detailed and systematic observations in the field than have heretofore been made will cause alterations in many of the pages, but the general scheme as presented will, it is confidently assumed, be found to approximate the truth.

A number of the articles have already appeared in substance in the Proceedings of the Academy of Natural Sciences of this city; these, where alterations have been found to be necessary, have been so modified as to bring them abreast of the time.

A. H.

PHILADELPHIA, *October*, *1884*.

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THE TERTIARY GEOLOGY OF THE EASTERN AND SOUTHERN UNITED STATES.

The United States Border Tertiaries and their European Equivalents.

The marine Tertiary deposits of the eastern United States occupy the outermost border (barring the post-Tertiary formations) of the Atlantic slope in a continuous extent from the neighborhood of Long Branch, N. J., to near, or quite to, the extremity of the peninsula of Florida. Beds referable to the same geological period have been identified on Martha's Vineyard, Mass., and good grounds exist for the supposition that similar beds extend beneath the water surface between this island and the New Jersey coast, and further to the northward. On the Gulf border the Tertiary deposits extend continuously through the States of Florida, Georgia, Alabama, Mississippi and Louisiana to a point on the Rio Grande in Texas at least (if not considerably more than) 60 miles N. W. of Laredo. Tennessee, Kentucky, Illinois and Missouri likewise contribute to the Tertiary area, while about one-half of the State of Arkansas is occupied by deposits of this age. On the Atlantic border the inner boundary line is removed from the coast by from about 25 miles, at a point opposite Trenton, to 160 miles in Georgia (near Macon). The deposits on the Gulf slope occupying the Mississippi embayment extend northward from the Gulf fully seven degrees, or about 500 miles, or nearly half way to the Canadian boundary line in Wisconsin.

The beds composing these deposits are in the north largely in the form of loose sands, clays, and marls, but in the south solid rock—shelly limestones, "buhrstone" —enters largely into their composition, more particularly of the older series. The dip on the Atlantic border, as also in Texas, Louisiana and Arkansas, is uniformly towards the S. E.; more nearly S. in Georgia, and S. by W. over a considerable portion of Alabama and Mississippi. Regarding the same in Florida little has been accurately determined. No disturbances of any moment appear to have intervened between the period of the deposition of the oldest member and the present day. In New Jersey, Delaware and Maryland, and again in Alabama, Mississippi, Tennessee, Arkansas and Texas, the deposits abut wholly or in part against those of the Cretaceous period (Sennonian and Mæstrichtian)—lying in some instances conformably upon them—while in some of the other States these last are completely (or nearly so) overlaid by them.

As to the ages indicated by the different members constituting the entire marine

Tertiary series, it may be premised at the outset that unequivocal representatives of both Eocene and Miocene exist; scarcely less positive is the existence of Oligocene deposits, whereas no satisfactory evidence has as yet been adduced proving the presence of Pliocene on our coast. The starting point in the correlation of the Eocenes is afforded by the well-known shell-sand layer of Claiborne, Ala., whose equivalency, at least in part, with the Calcaire Grossier of the Paris basin (Parisian), has long been recognized. The general similarity and identity existing between the fossil remains of the two localities here indicated place this determination beyond question. Beds representing the true "Claibornian" have been recognized in South Carolina, Georgia, Alabama, Mississippi and Texas, and doubtless some of the Eocene deposits in Arkansas and North Carolina belong to the same period. Underlying the "Claibornian" in the south are a series of clays, sands, and lignites, or in other localities, more or less siliceous and impure shelly limestones known as buhrstones—the "chalk hills"—several hundred feet in thickness, whose exact equivalence it is not as easy to demonstrate as those of the overlying sand beds, but which appear to hold a position somewhat parallel to that of the London clay (Londonian), or to the upper (and lower?) Suessonian of France. The "Buhrstone" (Siliceous Claiborne of Hilgard) occupies a considerable portion of the southern Tertiary area, attaining its principal development in Alabama, Georgia and South Carolina. In Alabama and Mississippi, as best studied in those States, with a probable development of 200-300 or more feet, we find at the base of the Eocene, a series of interstratified clays, sands and lignites, my "Eo-Lignitic," which seem to represent the most ancient of our cis-Mississippi Tertiary deposits. It appears probable that the oldest Eocene deposits occurring in New Jersey—those, for example, exposed on Shark River—belong here, and possibly also the Piscataway and Marlborough beds of Maryland and the Pamunkey sands of Virginia, which I have claimed to be the probable equivalents either of the British Thanet sands (or those of Bracheux, France), or of the British Bognor rock (lower Londonian). Not impossibly, however, they may prove to be the equivalents of a portion of the "Buhrstone." Immediately overlying the "Claibornian" in Alabama, Mississippi and South Carolina, with a considerable development in Louisiana and Georgia, and evidently also, although not as yet distinctly marked out, in Texas and Arkansas, are the deposits that have been designated the "Jacksonian," so named from the town of Jackson, in Mississippi, whence the fossils considered typical of this group were first obtained. In this series are included the so-called "white limestones" of many geologists, in which (and elsewhere) have been found, more or less abundantly, the remains of the Zeuglodon, the most distinctive fossil of the formation. No precise comparison between the fossils of this formation and those of correspondingly situated trans-Atlantic formations has as yet been instituted, and, therefore, it may perhaps be premature to assert with positiveness what the exact horizon represented by them may be. But as the beds occupy a position immediately overlying what is generally considered to be the next highest member of the typical European Eocene, as developed in the British and Paris basins, and underlying what can, I believe, be proved to be true Oligocene deposits, it may be reasonably inferred that they represent what in the basins referred to constitute the uppermost member of the entire series—the sands of Beauchamp and the Barton clay (= Upper Bagshot sands?). Confirmation of this view is afforded by the discovery in the Barton clay of Hampshire of the remains of a Zeuglodon (*Z. Wanklyni*, Seeley),[*] the only individual of the genus that has hitherto been found in any European formation. No really satisfactory evidence as yet exists as to the occurrence of Zeuglodon in any American formation but the "Jacksonian."

The so-called Oligocene deposits, to which reference has just been made, occupy in Alabama, Mississippi and Louisiana a narrow band of territory immediately to the south of, and bordering the "Jacksonian," which, as already stated, they also overlie. They occupy the greater portion of Florida, and doubtless also have a considerable development in southern Georgia and southeastern Texas, but in these last two States their areas have not as yet been accurately determined. They were originally called by Conrad, who first characterized them, the Vicksburg beds, and by me have been designated the "Orbitoitic," from the great abundance of *Orbitoides Mantelli*, their most distinctive fossil. Conrad referred the deposits in question to the Oligocene age not because they contained fossils in any way indicative of deposits of the same age in other countries, but merely for the reason that their contained fossils, as he supposed, were almost entirely distinct from those of the subjacent Eocene deposits, and equally distinct from those characteristic of the formations which he correctly surmised to be of newer date—the Atlantic Miocenes. This inference, I believe, can now much more satisfactorily be shown to be true. The *Orbitoides Mantelli* occurs in very considerable abundance in several of the West India Islands—Jamaica, Antigua, Trinidad—where the beds containing them are doubtless of equivalent age, and of the same age as the orbitoitic beds of Florida, and other of the southern States.[†] In the island of Trinidad they enter largely into the composition of the San Fernando rocks, which are by Guppy considered to represent the base of the Tertiary series of the islands, and which, together with the Chert formation in Antigua and the Anguilla beds, constitute a portion of his lower West Indian Miocene (in distinction to the principal Tertiary deposits of the island of Jamaica, the middle Tertiaries of San Domingo and Cuba, those of Cumaná, and the Caroni beds of Trinidad, which together form the upper or later part of the West Indian Miocene).[‡] These San Fernando beds have been more recently correlated by Duncan with the deposits occurring on the island of St. Bartholomew, which are emphatically stated to be of pre-Miocene age, and where no Miocene deposits have thus far been discovered to exist.[§]

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[*] Q. J. Geol. Soc., xxxii, p. 428.

[†] The species is also found in abundance in the lower limestone deposits of the island of Malta (T. R. Jones), in New Zealand (Karrer), and in Sinde, India (Carpenter).

[‡] Q. J. Geol. Soc., xxii, p. 282, 1866.

[§] Q. J. Geol. Soc., xxix, pp. 549–50, 1873.

The fossil coral fauna of this island is closely related to that of well-known Oligocene localities in Italy, as the Crosara and Castel Gomberto district, whose position in the geological scale they undoubtedly represent. This relationship is indicated by Duncan and other authors, and the writer is informed to the same effect by letter from Prof. Edward Suess, of Vienna, one of the profoundest workers in the field of the Tertiaries. The same eminent authority informs me that the Vicenza deposits above indicated are the unquestionable equivalents of the sands of Fontainebleau and of the marine Oligocene sands of the Mayence basin, and we thus have the parallelism established between our Vicksburg or orbitoitic beds and those of the typical Oligocene of southern Europe. The *Orbitoides Mantelli*, as already stated, also abounds in the lower limestone layer of the island of Malta,* and this layer has likewise been identified to be of Oligocene age, and to represent a part of the "Bormidian" of Sismonda, the older marine molasse of Bavaria and Switzerland, and probably also the Sotzka beds of the Vienna basin.† The relationship existing between the Florida orbitoitic rock and the deposits in some of the West India Islands which have been referred to the true Oligocene, is shown, irrespective of the great development of *Orbitoides Mantelli*, in the general character of the associated foraminiferal fauna. Thus we have in some places a sufficient abundance of *Operculinæ* (*Cristellaria rotella* of Conrad) and *Nummulinæ*,‡ and of species only doubtfully distinct from those found in Antigua, Trinidad or Jamaica. One or two other species of *Orbitoides* also occur, one very much of the *O. dispansus* type, and the other severely recalling *O. ephippium*. A further relationship with the equivalent St. Bartholomew deposits is established by the presence of at least two of the distinctive echinoids described from that island by Cotteau §—*Euspatangus Clevei* and *E. Antillarum*—and doubtless other identical forms will be found.

No unequivocal deposits of Miocene age have thus far been detected on the Gulf slope, although strong grounds exist for the supposition that the formation designated by Hilgard as the "Grand Gulf Group" belongs to this period of geological time, but to which division or horizon of the same, it is as yet impossible to state. On the Atlantic border the Miocene extends through the States of New Jersey, Delaware, Maryland, Virginia, North and South Carolina, and Georgia, following in a general way the trend of the Eocene, and, where not completely overlapping this last, lying between it and the coast. In North and South Carolina, also elsewhere, it is very largely obscured by deposits of post-Pliocene age. A patch of Miocene has been determined in the peninsula of Florida, near Rock Spring, in Orange Co., and not improbably a more or less continuous strip will be found to extend to this point southward from the

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* Geol. Mag., i, p. 104, 1864.

† Fuchs, Sitzungsb. K. K. Acad. Wissen. of Vienna, lxx, i, p. 92, 1874; see also Hoernes, Jahrb. K. K. Geol. Reichs., xxviii, pp. 30–36, 1878.

‡ Heilprin, Proc. A. N. Sciences of Philadelphia, July, 1882.

§ K. Svens. Vet.-Akad. Handl., 1874.

Georgia line, and possibly much further. A slight unconformability has in some places been detected between the Miocene and the Eocene. In a paper entitled "On the Relative Ages and Classification of the post-Eocene Tertiary Deposits of the Atlantic Slope"* I have given what I considered to be good reasons for concluding that the Miocene deposits of North and South Carolina, my "Carolinian," were of newer date than those of Virginia and Maryland, and that not improbably they represented the deposits of the lower ("Black") Antwerp crag, the Diestian of the Belgian geologists, although the percentage of recent forms is considerably higher in this last than that which has been shown to be the case with the Carolinian fauna. The Virginia and Maryland deposits, on the other hand, and doubtless with these also those occurring in Delaware and New Jersey, represent approximately the "Mediterranean" series of the Austrian geologists, and in their two divisions, the "Marylandian" (or older deposits of Maryland, and probably also the lower bed in Virginia) and "Virginian" (as developed in the typical Miocene area of Virginia, and in the upper Maryland series) we have the correspondents, at least in part, of the "First Mediterranean" (and the faluns of Léognan and Saucats), and the "Second Mediterranean" (and the faluns of Touraine) respectively. The southeast corner of Virginia, with the towns of Norfolk, Portsmouth, Suffolk, etc., appears to belong to the "Carolinian" horizon, or that of North and South Carolina. Comparing the Atlantic Miocene with deposits referred to the same age as occurring on some of the West Indies, Trinidad and San Domingo for example, we find that out of ten species of mollusca obtained from the Caroni beds of the first named island, Guppy identified no less than six as identical with forms found in the eastern United States: *Petaloconchus sculpturatus*, *Dosinia acetabulum*, *Tellina biplicata*, *Pecten comparilis*, *Ostrea Virginica*, and *Teredo fistula*.† This number is about equally distributed between the States of North and South Carolina and Virginia, and hence no absolute indication (by comparison) of the horizon is afforded by their presence. *Petaloconchus sculpturatus*, *Teredo fistula* and *Tellina biplicata* are also found in the Miocene of San Domingo, and with them *Chama arcinella* and *Arca pexata*,‡ but most of the species occurring here are described as being distinct from North American forms. Further investigation, however, will doubtless reveal a greater number of identical forms. While, therefore, it is still impossible from paleontological data to establish a strict correlation between the Caribbean and Atlantic Miocenes, yet probably we will not be far from the truth in assuming that the former represent a part of the Virginian or Marylandian series, seeing that the percentage of living forms in the contained fauna is only 20, or possibly still lower (8 or 9, according to Carrick Moore).§ They would, therefore, correspond to some part of the "Mediterranean" as well.

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* Proc. Acad. Nat. Sciences of Phila., June, 1882.

† Q. J. Geol. Soc., xxii, p. 576, 1866.

‡ Guppy, Q. J. Geol. Soc., xxii, p. 577.

§ Guppy, *op. cit.*, p. 575.

From what has preceded, the following table of the Atlantic and Gulf Tertiaries may be constructed:—

Post-Pliocene.			Foreign Equivalents.
Pliocene.	?	?	
Miocene.	**Carolinian.** (Upper Atlantic Miocene.)	Deposits of North and South Carolina ("Sumpter" epoch of Dana).	Diestian?
	Virginian. (Middle Atlantic Miocene.)	Deposits of Virginia, and the newer group in Maryland (" Yorktown" epoch, in part, of Dana).	Probably of the age of the " Second Mediterranean " of the Austrian geologists, and of the faluns of Touraine; Caroni beds of Trinidad; and Miocene of San Domingo, Jamaica and Cumaná?
	Marylandian. (Lower Atlantic Miocene.)	Older Miocene deposits of Maryland, and possibly the lower beds in Virginia (" Yorktown " epoch, in part, of Dana).	Probably (or at least partially) the equivalent of the " First Mediterranean " of the Austrian geologists, and of the faluns of Léognan and Saucats.
Oligocene.	**Orbitoitic.**	Strata characterized by species of *Orbitoides*. Vicksburg beds, Florida nummulitic beds, etc.	Aquitanian. Deposits of Crosara and Castel Gomberto (Vicentin), Oligocene of the Mayence basin, sands of Fontainebleau, lower limestone of Malta, Fernando beds on Trinidad, Antigua, Chert, St. Bartholomew Oligocene.
Eocene.	**Jacksonian.**	Jackson beds of Mississippi. " White Limestone " of Alabama.	Barton Clay (Bartonian). Sands of Beauchamp?
	Claibornian.	Fossiliferous arenaceous deposit of Claiborne, Ala., etc.	Age of the " Calcaire Grossier " of France (Parisian).
	Buhrstone.	Beds below the true Claibornian on the Alabama River, "Chalk Hills " of the southern part of the State, etc. " Siliceous Claiborne " (Hilgard) of Mississippi. Maryland Eocene, in part?	Londonian?
	Eo-Lignitic.	Lignite, sands and clays situated at the base of the Tertiary series in Alabama. etc. Marlborough and Piscataway beds of Maryland? Shark River deposits of New Jersey.	Thanetian? Bognor rock?

New Jersey.

The deposits of the Tertiary formations in this State follow in a general parallel course the trend of the next older or Cretaceous deposits (Mæstrichtian and Sennonian), upon which they can be shown in some places to lie conformably, or very nearly so.

Their inner border may be said to correspond in a general way with a S. W.–N. E. line connecting Long Branch, on the Atlantic coast, with a point on the Delaware River, situated almost due west of the city of Salem, or opposite Delaware City in the State of Delaware.* The surface embraced between the sea-border and this line comprises between one-third and one-half the area of the entire State, and presents in its physical features the characters of gravelly sands and clays.

EOCENE.—There can be no question but that the deposits of this period, forming part of the "Upper Marl Bed," so called, which appear along Deal Beach on the Atlantic coast, on Shark River, in isolated patches about Farmingdale, Squankum, and elsewhere, and in a more or less continuous belt from near New Egypt to Clementon, represent in part, if not in whole, approximately the lowest of the entire Eocene series occurring in the eastern United States. Their chronological equivalence with the oldest Tertiary beds occurring in some of the other States—as the Piscataway beds of Maryland, and the lower beds exposed on Bashia Creek, Clarke Co., Ala.—has not yet been definitely made out, but the evidence that has thus far been adduced is sufficiently strong in support of Conrad's original surmise as to the existence of such equivalence (Proc. Acad. Nat. Sciences of Philadelphia, 1865, p. 71; Smithsonian Misc. Coll., 200, 1866, p. 1). The fossils occurring in the New Jersey strata are mainly in the form of casts, and their precise determination is consequently involved in a considerable amount of uncertainty. It appears sufficiently clear, however, that many, if not most, of the forms are such as have not yet been found in the other States, although they represent distinctly Eocene types, but which approximate very closely certain trans-Atlantic species.

Those (invertebrate) specifically determined are, according to Conrad, the following:

Nautilus (*Aturia*) *Vanuxemi*, Conr.
Nautilus (*Cymomia*) *Burtini*, Nyst.
Nautilus (*Cymomia*) *Lamarckii*, Desh.
? *Rostellaria* (*Hippochrenes*) *columbaria*, Desh.
? *Voluta* (*Volutilithes*) *mutata*, Desh.
Pleurotoma (*Surcula*) *annosa*, Conr.
? *Pyrula* (*Pyrificus*) *Smithii*, Sow.
Pleurotomaria perlata, Conr.
Architectonica idonea, Conr.
? *Onustus* (*Phorus*) *extensus*, Sow.
Actæonema prisca, Conr.
Thracia modesta.
Caryatis Delawarensis, Gabb.
Protocardia curta, Conr.
Crassatella littoralis, Conr.
Venericardia perantiqua, Conr.
Yoldia protexta, Conr.
Avicula annosa, Conr.

(Cook, Geology of New Jersey, 1868, pp. 731–2; Check List of Eocene Fossils, Smiths. Misc. Coll., 1866.)

To these are sometimes, but erroneously, added *Arca quindecemradiata*, Gabb, *Crassatella Delawarensis*, Gabb, and *Terebratula glossa*, Conr.

It will thus be seen that the most distinctive Eocene forms found elsewhere, such as *Ostrea sellæformis*, *Ostrea compressirostra* (= *O. Bellovacina*?), *Cucullæa gigantea*, or *Cardita planicosta*, have not yet been discovered in this State. While, therefore, from paleontological evidence alone it would be impossible to indicate with precision the horizon which the New Jersey deposits hold relatively to the other Eocene deposits of the Atlantic and Gulf borders of the United States, yet from the presence of a number of organic forms which would appear to be indicative rather of an older than of a newer period, the absence of distinctively Upper Eocene species, and the circumstance that the beds in question occupy a position directly in line with the similarly placed older Tertiary deposits of Maryland and Virginia, whose age has been more definitely fixed (Thanetian ?), it may safely be premised that the horizon is near the base of the entire Eocene series.

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* Geological Map of New Jersey, 1882. Prepared by the Geological Survey of the State, under the direction of Prof. G. H. Cook.

MIOCENE.—Whatever may be the exact nature or age of some of the superficial deposits, as the "glass sands," occupying that portion of the State lying between the Eocene line and the coast, there can be little or no doubt existing as to the direct continuity throughout that portion of the State of the strata that have in Maryland and Virginia been designated the Miocene. Beds referable to this period have been identified in numerous areas throughout the region, and have in various localities been described as lying unconformably upon the Eocene, *i. e.*, with a less pronounced dip toward the sea. The fossils hitherto discovered in the deposits of this period are comparatively few in number, and have been obtained in principal part from the southern sections of the State, from the marl exposures in Salem and Cumberland (Shiloh) Counties.

Among the forms that have been identified with species occurring in other Miocene localities are:—

Ostrea Virginica (including *O. Mauricensis*).
Pecten Humphreysii.
? *Mytilus inflatus.*
? *Astarte exaltata* (*A. Thomasii*).
Astarte undulata (*A. distans*).
Crassatella melina.
Carditamera arata.
Yoldia limatula.
Corbula elevata.
Natica catenoides.

Other species, apparently confined to the State, are:—

Ostrea percrassa.
Plicatula densata.
Carditamera aculeata.
Mysia parilis.
Venus Ducatellii.
Venus plena.
Mercenaria cancellata, Gabb.
Tellina Shilohensis.
Thracia myæformis.
Anatina alta.
Saxicava (?) *parilis.*
Fasciolaria (*Turbinella ?*) *Woodii.*
Fulgur scalariformis.
Turritella æquistriata.
Turritella Cumberlandiana.
Turritella secta.
Fissurella Griscomi.[*]

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[*] Specimens of most of the species enumerated in the above lists are in the possession of the Academy of Natural Sciences.

It is very likely that both divisions of the Miocene indicated by me as occurring in Maryland and Virginia,[*] and by me designated as the "Marylandian" and "Virginian," or the lower and middle Atlantic Miocenes respectively,[†] will eventually be found to be equally well marked off in New Jersey, although up to the present time, from the sparseness of the fossil remains that have been collected, no such subdivision could be satisfactorily attempted. But from what material we have at hand, it may be safely asserted that the localities which have been so assiduously searched in the neighborhood of Shiloh, and elsewhere in Salem and Cumberland Counties, belong to the older or "Marylandian" division.[‡]

No satisfactory evidence has yet been brought forward proving the existence of any marine Pliocene deposits in the State.

Delaware.

We possess but very little precise information respecting the Tertiary formations of this State; no really accurate survey has here ever been carried into effect, and our present geological and paleontological knowledge of the region is based largely upon the "Memoir of the Geological Survey of the State of Delaware," of Prof. J. C. Booth, published in 1841. I am not aware that the Eocene formation has been absolutely identified by its fossil remains as occurring in the State, but no reasonable doubt can be entertained as to its existence there (although possibly entirely obscured by the newer Miocene deposits) as a direct continuation of, or connection between, the belts developed in Maryland and New Jersey. The northern boundary of the formation, corresponding to the southern boundary of the parallelly trending Cretaceous formation, will be found to lie along and somewhat to the north of the Appoquinimink, holding, probably, a more or less S. W.–N. E. direction. The southern third of the State appears to be in principal part covered by either very late Tertiary, or, what seems more likely, by post-Tertiary deposits; these are described as occupying the whole of Sussex County and the southern portion of Kent, defining the southern limit of the Miocene along the Murderkill and its tributaries. Prof. Booth recognizes two principal divisions in the Delaware Tertiaries, which he designates the northern and southern Tertiaries, but these have no special significance, being founded on purely geographical and lithological, and without reference to paleontological, characters. Still, more careful examination may prove them to correspond in a general way with the two Miocene divisions to which reference has already been made when treating of the geology of New Jersey. The invertebrate fossils specifically identified by Booth as occurring in the Miocene deposits are: *Venus alveata*, *Venus inocerami-*

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[*] Proc. A. N. S., 1880, p. 20, *et seq.*; 1882, p. 150, *et seq.*

[†] Proc. A. N. S., 1882, p. 184.

[‡] Heilprin: "On the Stratigraphical Evidence afforded by the Tertiary Fossils of the Peninsula of Maryland," Proc. A. N. S., 1880, pp. 31–2.

formis (*V. inoceroides*), *Nucula lævis*, *Myoconcha*, probably *M. incurva*, and *Pecten Madisonius*.

Maryland.

With respect to the Tertiary geology of this State we have very much more precise information than in the case of Delaware, although it must be confessed that a great deal still remains to be accomplished before an even approximately accurate delineation of boundary lines can be presented. This applies more particularly to the region of the East Shore, where the geological work done has been of a decidedly unsatisfactory character—a character that unfortunately only too well distinguishes the exploration of a very considerable portion of the Atlantic border. It is lamentable to find in the report of a survey published as late as 1860,* that work had not yet proceeded sufficiently far to permit of the subdivision of the Tertiary series into its primary component members (Eocene, Miocene and Pliocene), and this thirty years after the publication of Conrad's paper on the "Geology and Organic Remains of a Part of the Peninsula of Maryland"!†

The Cretaceo-Tertiary boundary line enters Kent County from Delaware at a point situated a few miles north of Millington, bisects in a southwesterly direction the peninsula formed between the northern head of Chesapeake Bay and Chester River, and continues on the west shore from a point a little outside of Annapolis to the neighborhood of Fort Washington, on the Potomac, a few miles below the city of Washington. South of this line to about the Little Choptank in Dorchester County, the region is occupied by the older and middle Tertiary deposits; the rest of the State southward and southeastward, consisting of loamy clays and sands, is considered to be of post-Tertiary date. The combined Tertiary and post-Tertiary areas cover nearly one-half of the entire State.

EOCENE.—The development of this formation on the East Shore has thus far not been accurately traced, but it may be assumed that its southern boundary lies somewhat between Chester River and Centreville. Chestertown and Millington doubtless both lie within its area. On the West Shore the formation has been more accurately studied, at least from a paleontological standpoint, but even here the exact boundary line, separating it on the southeast from the adjoining Miocene, has never been accurately defined. It may be said to correspond in a general way with a N. E.–S. W. line, drawn from the inlet known as West River, on the Chesapeake, to the mouth of Port Tobacco River, on the Potomac. In the area occupied by this formation, which consists of clays, marls, indurated sands, and, in some places, compact siliceous rocks, fossil remains, although somewhat restricted in variety, are sufficiently abundant, and comprise a number of forms, prominent by size, which are more or less distinctive of the State. The best known fossil-bearing localities are Fort Washington. situated a few miles below the city of Washington, Piscataway, on Piscataway Creek, and Upper Marlborough, in Prince George's County, which have been made known principally through the labors of Mr. Conrad.

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* First Report of Philip T. Tyson, State Agricultural Chemist, p. 43.
† Journ. A. N. S., vi, p. 205, *et seq.*

The positive determination of the relation which these older Tertiary deposits hold to the typical American Eocene series as exhibited in Alabama, can only be arrived at when a direct stratigraphical continuity can be traced between the deposits of the two States, or between their previously recognized representatives in the intervening States. This is due to the fact that several members of the Eocene series appear to be absent from this portion of the Atlantic border, but exactly which it has as yet been impossible to determine. The presence of strata of Jacksonian age has never been detected, nor have we any positive knowledge concerning the existence in the State of any beds which may be looked upon as the equivalents of the Orbitoide limestone, although Oligocene (Vicksburgian) strata may exist along the Chesapeake. But whether the deposits in question—Fort Washington, Piscataway, and Upper Marlborough—represent the Claibornian, Buhrstone or Eo-Lignitic is a matter of considerable uncertainty, perhaps largely due to their comparatively feeble development. Almost the only evidence we have bearing upon this point is derived from the character of the contained fossils, but even here the results obtained are far from satisfactory, and for two reasons: in the first place, the character of the Eocene fossils is largely uniform throughout the greater portion of the entire series, as is shown by nearly the lowest and highest exposures in the State of Alabama; and in the second place, the great distance intervening between the two localities—Alabama and Maryland—may readily account for certain differences in the general aspect of the two fossil faunas, which otherwise would probably be attributable to a non-contemporaneity in the periods of their introduction. The evidence afforded by lithological characters is almost equally unsatisfactory, since there is a frequent repetition of the general rock aspect—greensands, clays, and siliceous marls—observable at different stages of the series. Conrad, the only investigator whose observations on this subject are of scientific value, affirms that the majority of the fossil mollusca are of the Claiborne type, and he consequently correlates the beds containing them in a general way with those exposed on the Alabama River, although without specially indicating with what portion of the Claiborne section they were supposed to correspond. Indeed, about the only fossils obtained from the Maryland localities which can in any way be said to be either characteristic of or peculiar to them are *Panopea elongata*, *Pholadomya Marylandica*, *Pholas petrosa*, *Cucullæa* (*Latiarca*) *gigantea*, *Ostrea compressirostra*, and one or two doubtful species of *Crassatella*. All the species here named, if we except the doubtful Crassatellas and *Ostrea compressirostra*, are good species, and if we further deduct *Cucullæa gigantea*, the only Eocene species of the genera to which they belong thus far discovered in the eastern or southern United States. On the whole, therefore, they afford little or no clue to the exact determination of the age of the deposits in which they occur. It is true that an examination of the homotaxial deposits of Europe shows the genera *Pholadomya* and *Panopæa* to be more especially characteristic of the lower or even lowermost horizon, of the Eocene series, as in the English and French basins, but no special inference can be drawn from this circumstance, since the species are not the same, and the genera survived through the succeeding periods to the present day. In the case of *Ostrea compressirostra*, however, we have a much more tangible point. The species, first described and figured by Say (Journal of the Academy of Natural Sciences, iv, p. 133), is certainly very intimately related to the *Ostrea Bellovacina* of Lamarck, and apparently undistinguishable from certain varieties of that species.* Now this species, although not exclusively restricted to the lowest Eocene beds, is nevertheless highly characteristic of the Thanet sands, below the London Clay proper and also below what was formerly designated as the "Plastic Clay" series, where it constitutes a true basement accumulation; and it holds almost precisely the same relation to the beds of the Paris basin, where, according to Deshayes (*Animaux s. Vertèbres*, *Bassin de Paris*, ii, p. 117), it occupies the horizon of the Bracheux sands. The species, wherever found, appears to be considerably restricted in its vertical range, and its occurrence, therefore, in some of the American deposits would seem to afford some more decided indication of the true age of those deposits than could be obtained from the character of the limited number of its contained fossils taken as a whole. Associated with *Ostrea compressirostra* were found casts of the large *Cucullæa gigantea* (Conrad, Journ. Acad. Nat. Sciences, vi, p. 215, 1830), a species which appears not to be represented in any of the equivalent European formations. But in Virginia, in beds which can be shown to be the direct equivalents of those of Maryland, there occurs, in addition to the *C. gigantea* of Conrad, a second species of *Cucullæa*, the *C. onochela* of Rogers (Trans. Am. Philos. Soc., new ser., vi, p. 373; *Latiarca idonea*, Conr., Proc. Acad. Nat. Sci., 1872, p. 53—no locality stated), which, if not identical with the *C. crassatina* of Lamarck, from the Bracheux sands of the Paris basin, is certainly most intimately related to it, and can be considered in every way as its immediate representative.† It should also be stated that the only other species of *Cucullæa* described by Deshayes (*Animaux s. Vertèbr.*, *Bassin de Paris*, i, p. 109) from the Paris basin (*C. incerta*, Desh.) is found in the same horizon with the *C. crassatina*, and, likewise, the single species described by Searles Wood from the older Tertiaries of England is a *lower* Eocene form.

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* The distinguishing characters of the beaks pointed out by Say do not seem to hold in many instances, as is proved by specimens of the *O. Bellovacina* from the "London Clay" of Bognor, England, in the collections of the Academy, which do not differ as much from certain American specimens as these last do among themselves.

† I have had no specimens of the European species with which to institute direct comparisons, but as the species is a large one, and with well-defined characters, I have relied upon the figures and characters as furnished by Deshayes (*Coquilles Fossiles, Environs de Paris*, i, p. 193; Atlas, Pl. xxxi, figs. 8 and 9), which are well known for their accuracy. The *C. crassatina* is catalogued by Prestwich (Quart. Journ. Geol. Soc., 1854, p. 109) and Morris ("Cat. Brit. Foss.," p. 197) as being also an English form, and as belonging to the Thanet series, but by Searles Wood ("Monograph of the Eocene Mollusca" Bivalves, in Palæont. Soc. Publ., 1861, p. 84), the species occurring at Herne Bay, Faversham, etc., is considered to be distinct (*C. decussata*, Park.).

If such comparisons are of any value stratigraphically we may fairly look upon the Maryland Eocene deposits—the Piscataway sands below, and the Marlborough rock above—as representing a horizon nearly equal to that of the Thanet sands of England and the Bracheux sands of the Paris basin, or of the British Bognor rock (= London Clay).* In either case they would be near the base of the Eocene series.

In the scale of the American series as exhibited in Alabama they would occupy a position probably near the base of the "Buhrstone," or possibly even lower, as the equivalents of the beds exposed on Bashia Creek, and Cave and Knight's Branches ("Eo-Lignitic").

MIOCENE.—All the rest of the State southeast of the Eocene line, except such parts as may be covered by post-Pliocene deposits—Worcester, Wicomico, and portions of Dorchester and St. Mary's Counties—belongs to the Miocene formation. As in the case of New Jersey, no satisfactory evidence has as yet been brought forward proving the existence in the State of the Pliocene.

In a former paper † I have attempted to show that the post-Eocene Tertiary deposits of this State are divisible into two groups—an older and a newer, one of which —the newer—is unequivocally Miocene, and the other, possibly, Oligocene; both belong to a period antedating the principal post-Eocene deposits of the States of North and South Carolina. The deposits of the older group, which I have since designated as the "Marylandian," ‡ and have recognized as constituting the Lower Atlantic Miocene of the American coast, are best exhibited in the oyster banks, rising a few feet above tide-water, in Anne Arundel County, along the western shore of the Chesapeake, in the exposure of Calvert Cliffs, and in the Perna beds of the Patuxent River near Benedict.

Localities of the newer group are found at or near Cove Point, Calvert County, the Patuxent River, below and above Benedict (in the deposits overlying the Perna beds), and at numerous points along the St. Mary's River, in St. Mary's County. The proportion of recent species in the fossil fauna is here very much higher than in the deposits of the older group, and clearly indicates a considerable interval between the periods of the respective depositions. Beds belonging to the newer period, which I have elsewhere correlated with the principal Miocene deposits of Virginia (the "Virginian"), also occur on the East Shore, at Easton, on the Choptank, where the molluscan fossil fauna corresponds very closely with that observed on the west bank of the Patuxent. Connecting the points where the two series of deposits occur, it will be seen that the older group (Marylandian) occupies a northwestern area, or that adjoining the Eocene; and the newer group (Virginian) the area included between this last and that occupied by the post-Pliocene beds to the southeast.

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* The similarity existing between the Marlborough and Bognor rocks has been pointed out by Conrad (Proc. National Institution, p. 172, 1841).

† Proc. A. N. S., 1880, p. 20, *et. seq.*

‡ "On the Relative Ages and Classification of the post-Eocene Tertiary Deposits of the Atlantic Slope," Proc. A. N. S., June, 1882.

At the time that I prepared the article above referred to on "The Stratigraphical Evidence afforded by the Tertiary Fossils of the Peninsula of Maryland," wherein I indicated the existence and positions of the two divisions of the Maryland "Medial Tertiary," I was unaware that Conrad, some forty-five years before, had arrived at conclusions approximately identical with my own (although the data supporting his position were of a rather fragmentary and not exactly satisfactory character), but which he appears to have completely ignored at a later day. Thus in a paper on the "Tertiary Strata of the Atlantic Coast," published in 1835,* it is stated that between the Chesapeake Bay and Potomac River two classes of deposits occur "besides the equivalent of the London Clay or Eocene, the first of which, lying most to the westward, contains fewer recent species than the other, and is well characterized by the gigantic *Perna maxillata*." In my paper already referred to I have also stated that the lower or older beds are those which are characterized by *Perna maxillata*,† and it is just this species which is likewise largely disseminated through well-known Oligocene and older Miocene deposits of Europe. With it occurs *Mytilus incurva*, a large mytiloid form, which may be taken to be the representative of the *Mytilus Haidingeri* or *M. Faujasi*, forms also distinctive of the European Oligocene and Miocene.

Virginia.

The Tertiary formations of this State, for whose delineation we are principally indebted to the labors of Prof. W. B. Rogers and Mr. Conrad, pursue a more nearly meridional direction than in any of the other States that we have thus far been considering. The region occupied by them, designated also as the "Tertiary marl region," has been defined by Rogers‡ as embracing "nearly all that portion of the State included between its eastern boundary, the Chesapeake Bay and the Atlantic, and a hypothetical line intersecting the principal rivers at their lowest falls. Various beds of clay and sand, nearly horizontal in position, abounding in fossil shells, and the remains of large marine animals, form the characteristic strata of this division of the State, while occasional bands of iron ore, and beds of greensand, and a small portion of gypsum, occurring in connection with one of the fossiliferous deposits of the region, are among its other materials of value."

The inner boundary corresponds in a general way with a line passing from the mouth of Acquia Creek, on the Potomac, to the neighborhood (a little outside) of Fredericksburg, and thence through Wales, at the junction of the North and South

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* Am. Journ. of Science and Arts, vol. xxviii, p. 106.

† "There is, further, strong, although not conclusive, evidence for considering the beds containing *Perna maxillata* and *Ostrea percrassa* as the lowest of the series." Proc. A. N. S., 1880, p. 23.

‡ Report of the Geological Reconnoissance of the State of Virginia, 1836, p. 8.

Anna Rivers, tributaries of the Pamunkey, Richmond and Petersburg to the North Carolina frontier. For a considerable distance south of Petersburg this line has not been accurately traced, but its course shows a southwesterly deflection.

EOCENE.—From the line above indicated as forming the western boundary of the Tertiary in general the Eocene extends eastward in a narrow meridional strip, with a breadth varying from about 5 miles in the south to 12–15 miles in the north. On the west in its northern half it abuts upon the Trias, and in its southern half upon rocks of Archæan age. The absolute thickness of the formation appears nowhere to have been determined, and until more satisfactory data as to the amount of dip and the exact boundary outcrops be afforded, no reliable calculation can be made. But it would appear that in no locality where the beds are exposed does the visible development much exceed 30–40 feet. On the James River between Coggin's Point and City Point the thickness of the exposed strata is about 20 feet, and in the neighborhood of Mathias's Point, on the Potomac, opposite Port Tobacco in Maryland, which marks the eastern boundary of the formation, the thickness of the strata, as ascertained by Rogers, was very nearly the same, or 25 feet.

There is no reason for doubting that the Virginia Eocene deposits are a direct continuation of those of Maryland, as the position of the beds would readily suggest, and that consequently they represent an equivalent horizon. This conclusion is further borne out by the character of the fossil remains, which approximate closely to those of the State referred to, and among which we find such prominent large forms as *Ostrea compressirostra*,[*] *Cardita planicosta* (including *Venericardia ascia* of Rogers), *Turritella Mortoni*, *Cucullæa gigantea*, and the related *Cucullæa onochela* (Rogers; *Latiarca idonea* of Conrad), the last but doubtfully distinct from the *C. crassatina*, Lam., from the Bracheux sands of the Paris basin. The large saddle-shaped oyster (*Ostrea sellæformis*) which becomes such a prominent feature in the Eocene fauna of the more southern States, and one of whose deposits forms the basement layer in the famous Claiborne bluff on the Alabama River, appears to have had a much greater development here than in Maryland, where the remains of the species are very scanty.

MIOCENE.—The Miocene area extends from the Eocene boundary already defined to the sea, occupying what in principal part constitutes the tidal districts of the State. As in the case of the Eocene, there can be no question but that the deposits of this age form a direct continuation of the similar deposits of Maryland, and that consequently we have here approximately the same horizon or horizons represented. The division into the "lower" and "middle Atlantic Miocene," or what I have designated the "Marylandian" and "Virginian," does not, however, appear to be as distinctly marked off as in that State, the fossils indicating a more nearly uniform age (Virginian), but this seeming divergence may possibly be attributed to imperfect observation, or to a lack of observation. The discussion of the age of the beds here referred to, as well as of the equivalent deposits of Maryland, and their relations to the French faluns and the older Tertiary deposits of the Vienna basin, is fully set forth in my paper "On the Relative Ages and Classification of the post-Eocene Tertiary Deposits of the Atlantic Slope" (Proc. Acad. Nat. Sciences of Phila., June, 1882). It is not unlikely that the extremity of the State lying south of the James River, and including partly or wholly the counties of Southampton, Isle of Wight, Nansemond, Norfolk and Princess Anne (with the towns, among others, of Wakefield, Smithfield, Suffolk and Norfolk), as well as the extremities of the peninsulas included between the James, York and Rappahannock Rivers, belongs to a somewhat newer period than the region lying farther to the west, or more nearly that represented by the later Tertiary deposits of North and South Carolina—the "Carolinian" or upper Atlantic Miocene —whose continuation appears to be found here. The "fragmentary rock," consisting largely of comminuted and closely cemented shell fragments, described by Rogers [*] as occurring at various points on the eastern portion of the Miocene district, at Yorktown and Bellefield on the York River, and "near the extremity of all the peninsulas," and wherever occurring forming a distinctive feature in the stratigraphy of the region, is an indication of this newer formation. The existence of a newer division of the post-Eocene Tertiary in southeastern Virginia, although erroneously referred to the "Medial Pliocene," was already indicated by Conrad in 1835,[†] who assigned as localities for the same Yorktown, Suffolk and the James River near Smithfall (Smithfield?). A somewhat similar division of the Tertiary is made by Rogers, who, however, refers the newer division, with West Point, Norfolk, Suffolk, Wakefield, etc., to the Pliocene.[‡]

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[*] Specimen in the possession of the Academy of Natural Sciences from near Alexandria, right bank of the Potomac. Conrad, in his list of the Eocene fossils prepared for the Smithsonian Institution in 1866, confines the species to Maryland exclusively. Rogers, in his reports published in the American Philosophical Transactions (new series, vols. v and vi), makes frequent reference to this fossil, but, singularly enough, credits it with a position in the Miocene. It is not unlikely that in some instances, at least, the *O. disparilis* may have been mistaken for the form in question, to which it bears a striking resemblance. Nor does it seem unlikely that the *O. sinuosa* is more nearly *O. disparilis* than *O. compressirostra*, although stated to come from the Eocene greensands (Rogers, vol. v, p. 340; vol. vi, Pl. xxvii, fig. 1).

One of the most interesting components of the Virginia Miocene formation is the deposit of diatomaceous earth, with a development in some places of 30 feet, which is exposed near Richmond ("Richmond earth") and Petersburg, and which lies near the base of the system. It rests upon, or but little above the top of the Eocene, from which it is distinguished by the presence of occasional casts of Miocene shells, which clearly indicate its later origin. The same deposit has been traced to the Patuxent River and Herring Bay, on the Chesapeake, Md., and has been struck in an artesian boring at Fortress Monroe at a depth of 558 feet below the surface, likewise resting upon the Eocene.[§] We have here direct evidence bearing upon the thickness of the

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[*] Rep. Geol. Reconn., 1836, pp. 23–4.

[†] Am. Journ. Science and Arts, xxviii, p. 106.

[‡] Macfarlane's "Geological Railway Guide," 1879, p. 184.

[§] Rogers, in Macfarlane's Guide, p. 183.

Miocene deposits, and an indication of the dip of the underlying Eocene beds. If we assume with Rogers that the eastern outcrop of the Eocene formation above tide-water on a line west of Fortress Monroe is located at about the town of Waverly,* then we have for a horizontal distance of about 42 miles a descent of between 550 and 600 feet, or an average dip of 13–14 feet to the mile.†

North Carolina.

Most of the Tertiary deposits of this State are obscured by a capping of Quaternary gravel, sand and clay, which extends inwards for a distance of upwards of 100 miles from the sea. Beds belonging to both the Eocene and Miocene series occur in disconnected and limited patches, exposed principally in river excavations and bluffs. The exact horizon or horizons in the typical series which the Eocene beds represent, has not yet been satisfactorily ascertained, the paucity of fossil remains, and their divergence from the representative Eocene forms, preventing an absolute determination. The following list embraces most of the invertebrate forms, beyond indeterminable casts, that have been referred to the formation:—

Cidaris Mitchelii.
Cidaris Carolinensis.
Scutella Lyelli.
Mortonia (Periarchus) altus.
Microcrinus conoides.
Echinocyamus parvus.
Gonioclypeus subangulatus.
Flabellum (?) cuneiforme.
Dendrophyllia lævis.
Caryophyllia subdichotoma.
Lunulites contigua.
Lunulites sexangulata.
Lunulites distans.
Eschara tubulata.
Terebratula Wilmingtonensis.
Terebratula demissirostra.
Pecten membranacea.
Pecten anisopleura.
Pecten Carolinensis.
Nucula magnifica.
Lucina pandata.
Cardita rotunda.
Vivipara Lyelli.
Oliva Alabamensis.
Natica ætites.
Infundibulum trochiforme.‡

The Miocene clearly belongs to a period ulterior to the deposition of the principal Maryland and Virginia deposits, and represents approximately the South Carolina series ("Carolinian"). Owing to the superficial covering of Quaternary material it has been thus far impossible to determine with the desired precision the contour lines of the two formations, and hence on the accompanying map these (the inner boundaries) as represented must be considered as being largely hypothetical.

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* "Lower 19 Tertiary here probably above tide-level," in Macfarlane, p. 184.

† Through the kindness of Dr. Guillou the writer has obtained specimens from an artesian boring conducted at Newport News (June, 1882), in which he has been able to recognize fragments of *Pecten Humphreysii*, a form characteristic of the lower Atlantic Miocene ("Marylandian") of Maryland. The depth indicated for the fragments was 410 feet.

‡ The non-italicized names are given on the authority of Lyell, Q. J. Geol. Soc., i, pp. 431–32.

The following descriptions are borrowed from Kerr's report on the geology of the State*:—

EOCENE.—The distribution of the rocks of this subdivision is more limited than that of the Cretaceous, and much more so than that of the Miocene, which overlies it. The boundaries of it, north and south, are the Neuse and the Cape Fear; and it is found on the Neuse to within 2 or 3 miles of the railroad crossing, near Goldsboro', and at one point, in an isolated outcrop on the river bluff 7 or 8 miles further west; and it occurs in limited outcrops throughout the triangular region between Newbern and Goldsboro' and Wilmington. It consists of light-colored and yellowish consolidated marlites (bluffs of the Neuse 10 miles below Goldsboro', above Newbern, Natural Wells near Magnolia), shell conglomerates (about Newbern, Trent River), siliceous buhrstones, calcareous sandstone (near Goldsboro', Wilmington, etc.), gray and hard limestone, coarse conglomerates of worn shells, sharks' teeth, and fragments of bones and stony pebbles (upper part of Wilmington and at Rocky Point), or fine shaly, light-colored infusorial clays, as seen in Sampson County. Outside of the region bounded by the above points there are two or three patches of Eocene, one capping a hill 350 feet above the sea, on the railroad 7 miles east of Raleigh, a siliceous shell conglomerate of 2 or 3 acres in extent and 6 to 10 inches thick; the second, a ferruginous and calcareous sandstone of 4 or 5 feet thickness, on the top of a hill in the southeastern corner of Moore; this last containing some shells and many echinoderms. These fragments, or outliers, show that this formation, limited as it was in thickness, had a vastly greater horizontal extent than would have been suspected, and they carry the shores of the Eocene seas quite into the hill country of the State, and nearly 150 miles from the present coast line, and to an elevation of nearly 400 feet.

MIOCENE.—This subdivision of the Tertiary extends over nearly the whole seaboard region, from the sea-shore and the western margin of the sounds, 50 to 75 miles inland. It has a much greater horizontal extent than the preceding, and a greater thickness, but is less continuous, being found in disconnected patches, often of quite limited area, and exposed, like the preceding, only in river bluffs, ravines, ditches, wells, etc. It consists of beds of clay, sand and marl, which are locally filled with shells, more or less decayed, to a thickness of 2 or 3 to 6 or 8 feet, and occasionally 10 or 20. The formation thickens, deepens toward the northern border of the State, the beds being much thicker on the Tar and Roanoke than on the rivers south of them, and in fact being of such thickness here as to conceal both the Eocene, if it exists, and the Cretaceous, with a few quite local exceptions.†

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* Report of the Geological Survey of North Carolina, 1875, pp. 150–51.

† Kerr, *op. cit.*, pp. 150–51.

South Carolina.

The Tertiary deposits of this State occupy considerably more than one-half the superficial area, the territory comprised by them having a pretty nearly uniform width of 100–110 miles. The inner boundary line (as indeed is the case for almost the whole Atlantic border) conforms generally with the coast contours, and crosses the State in an almost direct northeast course from about opposite Augusta, in Georgia, via Columbia, to the North Carolina frontier. Throughout its entire extent the formation abuts upon granite or metamorphic rocks, gneisses, schists, and slates, whose exposures mark the first or lowest falls of the descending streams. The line of junction of the rocks of this series, consisting of sands, clays, marlites, and compact siliceous shell conglomerates, or "buhrstones," with those of the Archæan series, is indicated along the entire distance by deposits of sandy strata, which mark the line of distribution of the long-leaved pine (*Pinus palustris*), and support a vegetation essentially distinct from that of the rest of the State.

EOCENE.—Mr. Tuomey* recognizes three distinct divisions in this formation, respectively in the order of their position, beginning with the oldest, the Buhrstone, the "Santee beds," and the "Ashley and Cooper beds," the last two principally of a calcareous character, and corresponding to the "Carolina bed" of Ruffin. They form the basement of the so-called "Charleston Basin." The Buhrstone occupies the inner area of the Tertiary formation, extending over a continuous tract between the Savannah River and the Congaree, northwest of a sinuous line connecting Lower (Upper) Three Runs and Vance's Ferry on the Santee and passing on the inside of Allendale, Barnwell and Orangeburg. The thickness of this formation, which at many points along its southern edge and elsewhere can be seen to dip beneath or underlie the Santee beds, has been stated by Tuomey to be upwards of 200 feet, or as much as 400 feet. Its upper member is frequently a layer of greensand, which may be the representative of the similar layer that further to the south, in Alabama and Mississippi, marks the position of the true "Claibornian." However this may be, it is practically certain that the Buhrstone of Tuomey and the greensand together represent a very considerable, if not the greater portion of the deposits which in this State underlie the horizon of the typical "Jacksonian," as the character of the contained organic remains clearly indicates. Their approximate equivalency with the Buhrstone and "Claibornian" may therefore be assumed. Whether the calcareous strata occurring on the Santee below Vance's Ferry, and bordering upon the southern edge of the Buhrstone, be also referable to the "Claibornian" or not, or whether they constitute the correspondent of the "Jacksonian," we have as yet no satisfactory means of determining. It is true that a general similarity exists between their fossil remains and those of the older strata, yet there are a considerable number of forms which are not contained in the older rocks, as *Pecten membranosus*, *P. calvatus*, *P. perplanus*, *Conus gyratus*, several of the Echinodermata, etc., but which, or a number of which, on the contrary, are to be found in the supposed newer strata of the Cooper River, presently to be noticed. Furthermore, if the remains of *Zeuglodon* referred to by Tuomey as having been found in these deposits actually belonged there, and there appears to be no reason for supposing that the observation rests on erroneous data, then we are forced to admit that the beds in question represent a horizon above that of the Claiborne sands on the Alabama River, and more nearly that of the overlying white limestones. The evidence, then, is strong for concluding that the Santee calcareous strata form part of the true Jackson series.* In separating the Ashley and Cooper series from the Santee Mr. Tuomey appears to have been influenced principally by paleontological considerations, rather than by considerations drawn from stratigraphical position, although he alludes to the superposition of the beds in question over those of the Santee.† But if, as is contended,‡ many of the fossils of the Ashley are found on the Cooper, and elsewhere, but as a group they are very distinct from those of every other bed in the State, might it not be assumed, in the absence of facts proving direct stratigraphic continuity, that the two members (the Ashley and the Cooper) of the series indicated are in themselves distinct? But yet they are grouped as one by Tuomey, and not improbably so with reason. And if one, why separate the series from the Santee? We fail to discover from Tuomey's writings that any material difference exists between the faunal facies of this last and the deposits exposed on Cooper River; on the contrary, a very considerable number of the forms are common to both, and among these we have the forms that have already been referred to, *Pecten membranosus*, *P. calvatus*, *P. perplanus*, *Conus gyratus*, etc., besides the Zeuglodon, which ranges through the Santee, Cooper, and Ashley beds. There appears to me to be no good reason for separating the above deposits from each other as indicative of special horizons, although they may occupy different stratigraphical positions in the geological scale, and, therefore, I have retained them as one group, the correspondent of the "Jacksonian."

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* Report of the Geology of South Carolina, 1848.

OLIGOCENE.—What the precise age of the beds on Tinker's Creek and along the Savannah opposite and below Shell Bluff, in Georgia, containing *Ostrea Georgiana*, is—whether upper Eocene ("Shell Bluff" group of Conrad) or Oligocene—still remains to be determined. It appears not unlikely that Hilgard's supposition as to their being of Vicksburg age,§ and their correspondence (as was maintained by Conrad) with the oyster-bed underlying Vicksburg Bluff on the Mississippi River, whose position is between the Jackson and the Vicksburg, is a correct one, although the evidence on this point is not yet absolutely confirmatory. Most of the fossils[*] obtained by Lyell from the face of Shell Bluff are forms that have been identified as exponents of the typical Eocene—"Claibornian" and Buhrstone—but we are not clearly informed what relative position these held to the Georgiana layer, or the layer containing the giant oyster. More direct information on the point in question is given by Ruffin,[†] who asserts that the oyster-bed, with a development of 4–6 feet, occupies the top marl layer of the bluff overlying what he unhesitatingly calls the "Great Carolinian bed," and which, as we have already seen, is the correspondent in part or in whole of the "Jacksonian." If these observations are to be trusted in their entirety, then there can be but very little room left for speculation on the subject—either the oyster layer forms a part of the Jackson series, or belongs to a deposit of newer age, doubtless the Vicksburg (or Oligocene).

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* *Ostrea panda*, one of the distinctive Santee fossils, is found abundantly in the basal portion (Jackson) of St. Stephen's Bluff, on the Tombigbee River, Ala.

† *Op. cit.*, p. 162.

‡ *Op. cit.*, p. 163.

§ Am. Journ. Science, new series, vol. xlii, pp. 68–70.

MIOCENE.—The post-Eocene Tertiary deposits of South Carolina, considered by Tuomey and Holmes to be of Pliocene age, but here referred to the Miocene, occupy, as seen by their outcrops, principally the northeast section of the State, and are most largely developed in Horry, Marion, Darlington, and Sumter districts. As in North Carolina they appear mostly in isolated patches, filling depressions in the underlying Eocene or Cretaceous strata, either along exposed river sections, or on elevated spots that have effectually resisted denudation. South of the Santee River the formation has been traced on the Cooper and some of its tributaries, extending within a few miles of the city of Charleston, and an outlier is noted by Mr. Tuomey as existing on the Edisto below Givham's Ferry. Unfortunately the actual extent of the formation under consideration is not sufficiently well known to permit of its accurate representation on the map, and, therefore, the boundaries there indicated must still be considered in a measure hypothetical. It appears not unlikely that a connecting tract of Miocene exists between the Georgia and South Carolina areas; at any rate, the Edisto deposit above referred to would seem to indicate such connection.

Georgia.

No accurate detail work on the Tertiary geology or paleontology of this State has thus far been attempted; at any rate, no results of such work, if made, have as yet been published. Our knowledge of the subject is still, therefore, mainly of a general or fragmentary character, and not sufficiently precise to permit of its use in either definitely locating the boundaries or defining the approximate extents of the various formations. It is, however, positive that we have here representatives of both Eocene and Miocene, and not unlikely the former is represented in all or nearly all the various divisions which collectively characterize the formation along the Atlantic and Gulf slopes—*i. e.*, "Eo-Lignitic," "Buhrstone," "Claibornian," and "Jacksonian"—although these divisions have not yet been clearly made out. The Buhrstone appears to occupy the greatest extent; at any rate, whether correctly or incorrectly, it is the formation generally referred to as the typical Georgia Eocene. The Jackson doubtless enters the State along the southern border, although I am not aware that its existence there has been definitely determined through the character of its fossil remains. Mr. Ruffin's determination (?) of the "Great Carolinian Bed" (= Jacksonian) in Shell Bluff, on the Savannah River, has already been referred to in our description of South Carolina, and needs no further comment here Leaving aside the probable existence in the State of the Oligocene formation, as would seem to be indicated by the Georgiana bed, or bed containing the giant *Ostrea Georgiana*, overlying the marl deposits (Ruffin's "Great Carolinian") of Shell Bluff, it is almost positive that the formation in question occupies some little, if not a considerable section of the lower Tertiary area, continuous with the area occupied by the same formation in Florida The later Tertiary deposits occupying the Atlantic border, and having an extent landward of about 60 miles, are probably continuous with, and doubtless of the same age as the later Tertiary deposits of South Carolina, and are accordingly referred to the Miocene.

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[*] Oliva Alabamensis, Pyrula sp., Turbinella (Voluta) prisca, Melongena alveata, Infundibulum trochiforme, Natica ætites, Crepidula lirata, Dentalium thalloides, Ostrea sellæformis, Nucula magnifica, Cardita rotunda, C. planicosta, Crassatella protexta, Lucina pandata, Cytherea perovata, C. Poulsoni, Lutraria lapidosa. Lyell, Q. J. Geol. Soc., 1, p. 437.

[†] Rept. Agricult. Surv. of South Carolina, 1843, pp. 22–3 and 34.

The Tertiary deposits, which in their entirety occupy considerably more than one-half the area of the State, doubtless rest upon a Cretaceous floor, and abut for the greater part of their extent upon rocks of Archæan age. Their inner boundary corresponds approximately with a moderately sinuous line running from near (a little outside of) Augusta, on the Savannah, by way of Macon, Fort Valley, Montezuma, Americus and Cuthbert, to Fort Gaines, on the Alabama frontier.*

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* Since the preparation of the above the writer has received, through the kindness of the author, Dr. Loughridge's notes on the geology of the State (Report on the Cotton Production of the State of Georgia, pp. 14–16; extracted from the Tenth Census Reports, 1884), which, unfortunately, are too brief to add very materially to our knowledge of this division of the geological history. The following section, taken from Mr. Singleton, is given of Shell Bluff, Burke Co. :—

1.	Red loam hill tops, ...	15–25 feet.
2.	White sandy marl, coarse sand and oysters—*Ostrea Georgiana*, .	10 feet.
3.	Coarse drift and shell fragments, ...	2 feet.
4.	Shell bed—*O. Georgiana*, ...	13 feet.
5.	White sandy marl, ...	60 feet.
6.	Indurate marl, with casts of small shells, ...	2 feet.
7.	White sandy marl, ...	6 feet.
8.	Indurate marl, with casts of shells and few *Ostrea selliformis*, .	3 feet.
9.	Hard yellowish white marl, ...	4 feet.
10.	Oyster-bed—*O. selliformis*, ...	1 foot.
11.	Hard marl, ...	5 feet.
12.	Oyster-bed—*O. selliformis*, ...	6 inches.
13.	Hard yellowish-white marl, ...	10 feet.
14.	Fine yellowish sandy marl, ...	6 feet.
15.	Yellowish-white clay marl, ...	2 feet.
16.	Indurate marls, with shells, ...	2 feet.
17.	Whitish-gray clay marl (to water), ...	15 feet.

The beds containing *Ostrea Georgiana* are referred to the Vicksburg series; No. 5 not improbably represents, either in part or in whole, the "Jacksonian," while the lower portion of the bluff is doubtless largely of the

Florida.

The geological relations of the rocks of this State, as well as the history of their exploration, are clearly set forth in a paper by Prof. Eugene A. Smith, entitled: "On the Geology of Florida," and published in the American Journal of Science, 3d series, vol. 21. It is there conclusively shown that the views entertained by Louis Agassiz and Joseph Le Conte as to the recent and coralline formation of the peninsula are essentially erroneous, and that, as a matter of fact, the greater portion of the peninsula dates back to the Oligocene period, or to the period of the Orbitoitic limestone. Substantial proof of this fact is afforded by the numerous localities where fossils—very largely the genus *Orbitoides* itself, with the species *O. Mantelli*, and others—distinctive of the Orbitoitic formation have been discovered, as in the stretch between Tampa Bay, where they were first identified by Conrad nearly forty years ago, and the Georgia line. Beside the localities where fossils of this class were determined by me to characterize the rock formation, to which reference is made by Dr. Smith, other areas of a like nature have since been discovered, and most notably, perhaps, the territory about Cedar Keys, where, from rock specimens submitted to me by Mr. Joseph Willcox, I was enabled to detect the existence of a true Nummulitic rock, or a rock made up very largely of the united tests of principally one form of Nummulite.[*] This rock, which is found in the immediate neighborhood of the Cheeshowiska River, in Hernando County, about four miles from the coast, contains in addition to the mass of Nummulites of which it is so largely made up, a sufficient abundance of *Orbitoides*, and also the foraminiferal form which Conrad described as *Cristellaria rotella*, but which I have referred to *Operculina*.[†] From a locality further to the north, Wacassassa in Levy Co., rock specimens submitted to me were found to contain a number of Echinoids of the genus *Euspatangus*,[‡] referable specifically to the forms described by Cotteau from the Oligocene deposits of the island of St. Bartholomew, as *E. Clevei* and *E. Antillarum*.[§]

From what has preceded, taken in connection with the observations that have been made in western as well as in northern Florida, it may safely be conceded that the underlying rock of the greater portion, if not of nearly the entire State, is of Oligocene age, and therefore no countenance is given to the theory which assumes a recent for-

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"Claibornian" age. The Miocene tract, whose rock masses are stated to closely resemble the Grand Gulf sandstone of the Gulf States, is claimed to have a much broader extension than we have above indicated, for if the outcrops observed in Irvin and Dodge Counties really belong to the period in question, which may perhaps still be considered as not yet satisfactorily established, then the inner boundary of the formation will be removed from the coast by about 130 miles. [The Miocene area on the map is according to Loughridge.] The rocks have a slight dip to the southeast, and on the Oconee, where they have been traced for a distance of 60 miles, their development is stated to be 200 feet.

[*] *Nummulites Willcoxi*. Heilprin, "On the Occurrence of Nummulitic Deposits in Florida, and the Association of Nummulites with a Fresh-water Fauna," Proc. A. N. S., July, 1882.

[†] The species is not impossibly identical with *O. complanata*.

[‡] The generic determination kindly made for me by Prof. Alexander Agassiz.

[§] K. Svens. Vet.-Akad. Handl., 1874.

mation. How far south the Orbitoitic limestone extends has not yet been determined, but there appear to be no reasons for assigning it to a limit far removed from the border line of the Everglades. For aught we know to the contrary it may extend quite or nearly to the peninsular extremity.

Barring the post-Pliocene of the coast, the only indication that we as yet have of the existence of any marine formation in the State newer than the Oligocene is the patch of limestone referred to by Dr. Smith *—as occurring at Rock Spring, Orange Co., from which have been obtained specimens identified by me as belonging to the Miocene period—*Pecten Madisonius*, *Venus alveata*, *Cardita granulata*, *Carditamera arata*, and doubtfully, *Mytiloconcha incurva*, *Cardium sublineatum* and *Oliva litterata*. Other Miocene areas will doubtless be discovered, and not impossibly a more or less continuous belt will be found to unite the Rock Spring patch with the Miocene area in Georgia.

Alabama.

The Tertiary formations of Alabama, which occupy a tract in the southern part of the State with a general width varying from about 55 to 90 miles, seemingly exhibit equivalents of all the various subdivisions that have been recognized on either the Atlantic or Gulf borders as intervening between the base of the system and the Vicksburg beds (Oligocene). The Eocene appears here clearly defined in its four divisions, the Eo-Lignitic (Thanetian?), Buhrstone (Londonian?), Clairbornian (Parisian, or Calcaire Grossier), and Jacksonian (Bartonian), which follow each other in a general succession (commencing with the lowest) from north to south. Covering the Jacksonian, and occupying a belt immediately to the south of it, are the Vicksburg beds, whose most southern exposure on the Alabama River is at or near Gainestown, some eighty miles north of the Gulf, where the strata pass under the beds that have been designated by Hilgard as the "Grand Gulf Group." Whatever the exact age of the deposits of this group may be, they are the only ones of marine or fluvio-marine origin that indicate along the Gulf border a Tertiary formation of newer date than the Vicksburg; whether they belong to the Miocene period, as has been suggested by Hilgard, or to the Pliocene, can only be ascertained when a more thorough examination of their fossil remains will have been attempted than has heretofore been practicable. For their entire extent the Tertiary deposits abut against those of Cretaceous age, the two having a very nearly equal development, and together occupying about one-half the area of the State. In their eastern half the outcrop or strike of the strata is more nearly due east and west, with a moderate dip to the south, while in the western half the line of outcrop is W. by N.—E. by S., with a dip S. by W. of about 10 feet to the mile.

A convenient starting point in the Tertiary stratigraphy of the State is afforded by the famous bluff exposed on the Alabama River near Claiborne, which has yielded the fossils known to geologists and paleontologists as those characteristic of the "Claiborne Group." Probably the most trustworthy section of this bluff is that given by Tuomey,* as follows:—

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* *Loc. cit.*, p. 302.

		Feet.
g	Red sand, loam, and pebbles.	30
f	Mottled clay.	8
e	Limestone, with grains of greensand.	54
d	Ferruginous sand; numerous fossils.	
c	Whitish limestone.	62
b	Bed of clay 15 feet thick, with seam of limestone on top.	15

Note.—Tuomey does not give the thickness of bed "*d*," but it appears from the concurrent statements of different observers to be about 17 feet. The total height of the bluff above the Alabama River would therefore appear to be in the neighborhood of 190 feet.

The measurements and descriptions of Conrad,† Hale,‡ and Lyell,§ do not differ very materially from the data given by Tuomey. The arenaceous bed "*d*," about 80 feet above water-level, has yielded the vast majority of fossils for which the locality is famous, and is that which has been identified as the equivalent of the "Calcaire Grossier" (Upper Eocene of France = Bruxellian of Belgium). Although formerly considered to be near the base of the system, there are now very strong grounds for concluding that these beds are underlaid by older Eocene strata, having a thickness at least 300 feet, and, possibly considerably more. The age of the limestone bed "*e*," although perhaps the character of its contained fossils does not permit of absolute determination, is doubtless at least in part Jacksonian, and will be found to correspond with a portion of the bluff exposed at St. Stephen's on the Tombigbee River, about thirty miles almost due west of Claiborne. At any rate, a portion of the white limestone west of Claiborne has been found to contain several of the characteristic fossils of the Jackson group, and these associated with the remains of *Zeuglodon;* there is, therefore, no doubt as to the age of at least this portion of the white limestone, nor can there be any reasonable doubt as to the continuity existing between these deposits, and the similar ones exposed on Claiborne bluff.

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* First "Biennial Report of the Geology of Alabama," 1850, p. 152.

† "Fossil shells of the Tertiary Formations," 1833, p. 32; Proc. of the Nat. Institute, 1841, p. 174.

‡ "Geology of South Alabama." Am. Jour. of Science, new ser., vi, p. 354.

§ Q. J. Geol. Soc., iv, p. 10, *et. seq.*

SECTION ON BASHIA CREEK, CLARKE CO.—Probably the section representing the oldest Eocene deposits of the State is that exposed on Bashia Creek, detailed by Tuomey in his "First Biennial Report," p. 145:

1	Hard Limestone.	4 feet.
2	Marl, highly fossiliferous.	25 feet.
3	Blue sand.	Variable.
4	Lignite and clay.	6 feet.
5	Laminated clay, sand, and mud.	Thickness undetermined.
6	Lignite.	do. do.

NOTE.—Beds 5 and 6 do not properly belong to the section, but "represent beds seen on another part of the stream below the preceding" (Tuomey, *loc. cit.*, p. 146).

Beds corresponding to No. "2" of the above section are likewise exposed on Cave and Knight's branches, tributaries of Bashia Creek, and have been shown by Dr. Eugene A. Smith to underlie the *base* of the "Buhrstone" proper by nearly (if not more than) 200 feet.* The relations of these various beds will be best understood by a reference to the sections exposed on the Tombigbee River.

SECTIONS ON THE TOMBIGBEE RIVER.—At Wood's Bluff, near the mouth of Bashia Creek, we have the following exposure:—

No.		Feet.
7	Orange sand, or stratified drift.	10–20
6	Grayish or greenish laminated clays, colored brown by iron.	10
5	Ledge of bluish or greenish sand, fossiliferous—capped by a ledge of hard nodules.	2
4	Bluish laminated clay, with few fossils.	5
3	Indurated greenish sand, full of the same shells as marl bed No. 2.	3
2	Greensand marl, quite soft, and full of shells.	3
1	Indurated greensand with shells, and a stratum of oyster-shells at water's edge—said to extend 10 feet further down.	10–15

Bed No. 4 is considered by Dr. Smith to be most closely related in the character of its fossil remains to the fossiliferous strata exposed on Cave and Knight's branches, and it is therefore not unlikely that the series 1–5 correspond in the main with No. 2

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* Heilprin, Proc. Acad. Nat. Sciences, 1881, p. 369.

of Tuomey's Bashia section* The basal lignite would then probably be found to underlie the lowest stratum exhibited at the Bluff. Bed No. 6 (Wood's Bluff section) can be traced down the river for a distance of two or three miles, when it dips beneath the water's level. Somewhat below this point, and beyond the mouth of Witch Creek, the stratigraphical relation of the different beds is beautifully exhibited in a prominent cliff ("White Bluff"), rising from 250 to 275 feet above the river. The upper portion of this bluff is constituted by the characteristic siliceous clay-stones and silicified shell deposits of the southern "Buhrstone" formation, which make up fully 100 feet of the vertical height. Laminated lignitic clays (bearing numerous leaf impressions), with occasional intercalated beds of pure lignite, enter mainly into the composition of the intermediate portion, *i. e.*, from the water's level to the base of the buhrstone above mentioned. Allowing a uniform southerly dip of 10 feet to the mile, which appears to be consistent with obtained data, it is manifest that at this point the lowest fossiliferous strata exposed at Wood's Bluff (and consequently the equivalent deposits on Bashia Creek and its tributaries, Cave and Knight's branches) must lie from 175 to 200 feet below the base of the siliceous mass constituting the true buhrstone; or in other words, we have here a series of deposits aggregating about 300 feet in thickness, which can be shown to be of an age anterior to the deposition of the Claiborne fossiliferous sands. At Baker's Bluff, a few miles above St. Stephen's (which is situated some twenty-eight miles south of Wood's Bluff), the buhrstone, according to Tuomey, appears in a vertical escarpment rising only 50 feet above the water, a low height perfectly in accordance with the loss occasioned by the general dip extending over nearly twenty miles. At this point, moreover, occupying a position above the buhrstone, Tuomey (*op. cit.*, p. 148) identifies a bed of greensand, 8 feet in thickness, as the equivalent of the Claiborne fossiliferous sands ("*d*" of his section), and containing numerous fossils identical with those found at Claiborne. Still further south, and occupying a considerably lower level, the same bed is described as having a development of 12 feet, and immediately above St Stephen's was seen to dip beneath the water's edge. At this last locality we have a beautiful exhibit of what has generally been designated by the name of "White Limestone."†

There can be not the least doubt, however, that this "White Limestone," which has most frequently been taken to represent bodily the Vicksburg (Oligocene or "Orbitoitic"), is in reality, as has been long ago insisted upon by Winchell,‡ a combination of strata belonging to two distinct groups of deposits. The lower moiety, dipping into the river, and resting upon the subjacent Claiborne sand (Tuomey, *op cit.*, p. 157; Lyell, Q. Journ. Geol. Soc. Lond., iv, p. 15; Hale, A. J. Science, new ser., vi, p. 359), is the true "White Limestone," an exponent of the Jacksonian group of deposits, as is clearly indicated by the character of its contained fossils.* Were it otherwise the case, it would be very difficult to explain the total disappearance over a distance of only thirty miles (and with but exceedingly moderate dip) of the equivalent beds exposed on the Alabama River at Claiborne. The upper moiety, on the other hand, is a portion of the well-known Orbitoide (Vicksburg or Oligocene) rock, and is that which alone contains specimens of *Orbitoides Mantelli* (Winchell, *loc. cit.*, p. 85).

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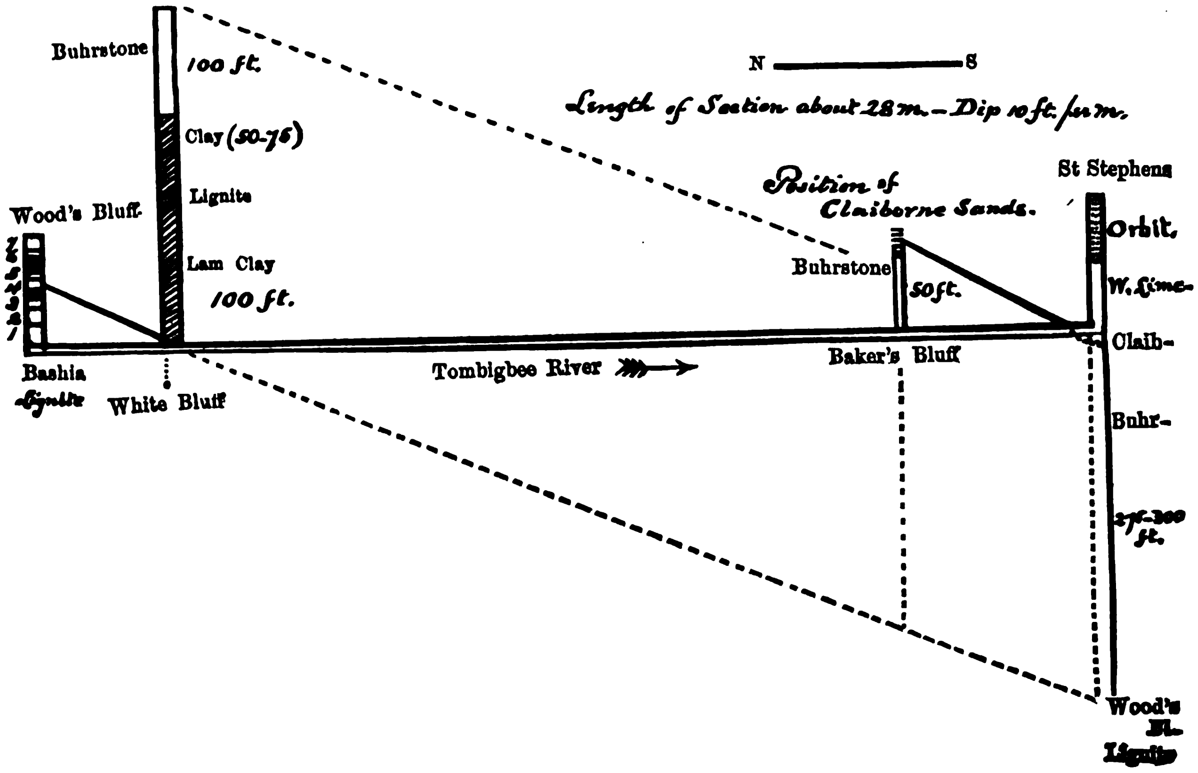
* The relations of the Bashia and Wood's Bluff sections, as well as those of Cave and Knight's branches, are fully set forth in my paper above referred to, Proc. A. N. S., 1880, pp. 364–70.

† I have been unable to discover the exact height of this bluff. Neither Lyell nor Tuomey mentions it; Conrad, in the appendix to Morton's "Synopsis" (p. 23), states it is about 100 feet.

‡ Proc. Amer. Assoc., 1856, part ii, p. 85.

From the data here presented, a section of the Tertiary strata traced along the Tombigbee River from Wood's Bluff to St. Stephen's, may, with considerable approach to truth, be constructed as follows:—



The foregoing section shows almost conclusively that the Eocene deposits of Alabama have a thickness of very nearly 400 feet; and, indeed, Dr. Smith, State Geologist, informs me that there are good grounds for supposing that Tertiary beds occur along the northern outcrop, whose position would be still 150–180 feet below the Wood's Bluff marl bed. It will further be seen that the "Claibornian" (or Claiborne proper, as characterized by the fossiliferous greensands) holds a position decidedly near the top of the series, a position almost precisely similar to that occupied by the "Calcaire Grossier" (Parisian) of France, more properly Upper than Middle Eocene, which last it has very generally been considered. What relation beds "*b*" and "*c*" of the Claiborne Bluff hold to the sub-Claibornian ("Buhrstone" in part) deposits of the Tombigbee River has not yet been absolutely determined; but there can be no legitimate doubt that they represent, in a modified form, the upper moiety of those deposits. Although the marked difference in the lithological character of the strata of the two localities as compared with each other (and, indeed, it must be confessed, this is much greater than could have been reasonably inferred from the general constancy of the deposits in this region) would seem to militate against such a view, there is, nevertheless, sufficient evidence, both stratigraphical and paleontological, to support this conclusion. In the first place, by determining the position of the buhrstone rock near St. Stephen's as immediately underlying the highly fossiliferous greensand layer, Tuomey has proved that the two series of deposits (the "Buhrstone" on the Tombigbee, and bed "*c*" on the Alabama) hold relatively the same position to the true Claibornian, lying immediately below it. In the second place, the argillaceous strata at the base of Claiborne Bluff (bed "4" of Hale's series) have been identified by Hale, both on lithological and paleontological evidence (A. J. Science, new ser., vi, p. 356), as occurring at Coffeeville Landing on the Tombigbee River, about fourteen miles north of St. Stephen's, what might very readily have been expected from an inspection of the general lay of the different formations.* No data are given relative to the position of the "Buhrstone" at this last locality, but hypothetically considered (as deduced from its position at White Bluff, and its general dip), its summit must still occupy a position fully 100 feet above the level of the river; and this thickness (100 feet) coincides very closely with the thickness (80–90 feet) of the deposits below the true Claibornian (bed "*d*") as exposed in the bluff on the Alabama River. And finally, that at least a very considerable portion of the inferior beds at this last-named locality represent strata of a different lithological character in other portions of the State—and consequently, that they are local deposits—is proved by the concurrent statements of Hale (*loc. cit.*, p. 356) and Winchell (*loc. cit.*, p. 86), both of whom assert that the calcareous deposit below the arenaceous bed (not the "White Limestone") is not known to occur at any other locality.

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* *Spondylus dumosus* and *Ostrea panda*, originally described as characteristic fossils of the newer Cretaceous (upper Eocene) of the southern United States, have been found abundantly near the base of the bluff.

From the data here presented, it will be seen that the Alabama Eocene formation comprises:

4. "White Limestone" (Jacksonian), best exhibited at Claiborne (upper portion of bluff) and St. Stephen's (lower moiety of bluff), not very abundant in fossils—*Pecten membranosus*, *P. Poulsoni*, *Ostrea panda*, *Spondylus dumosus*, "*Scutella*" *Lyelli*, etc.—50—? feet.

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* A line uniting Claiborne and Coffeeville Landing would run almost precisely parallel with the line marking the junction of the Cretaceous and Tertiary deposits lying hence due north. The contour lines traced by Tuomey would indicate a *true* dip west of the southerly line, and that this is actually the case is proved by the difference (80–90 feet) between the actual heights at which the equivalent beds at St. Stephen's and Claiborne are placed. This also agrees with Hilgard's observations in Mississippi, where the dip of the Jackson and Vicksburg strata was found to be about 10 to 12 feet per mile S. by W. (A. J. Science, new ser., xliii, p. 36).

3. The fossiliferous arenaceous deposit (Claibornian), best shown at Claiborne—subaqueous at St. Stephen's—very rich in fossils, and of the age of the "Calcaire Grossier" of France.—17 feet.

2. "Buhrstone" (Siliceous Claiborne of Hilgard), comprising siliceous clay-stones (buhr-stone proper) densely charged with fossils or their impressions, laminated clays, sands and calcareous deposits—beds "*b*" and "*c*" of the Claiborne section, the cliff at White Bluff, and the so-called "Chalk Hills" of the southern part of the State. At Claiborne the representative beds consist of aluminous and calcareous deposits, poor in fossils, but containing occasional layers of *Ostrea sellæformis*.—About 250 feet?

1. The Wood's Bluff and Bashia (with Cave and Knight's Branches) deposits (Eo-lignitic), consisting of alternating dark clays, greenish and buff sands, and numerous seams of lignite, partly very rich in fossils, and as far as is yet *positively* known, the oldest Tertiary deposits of the State.—50—? feet.[*]

The exact development of the Vicksburg (Oligocene) and Grand Gulf (Miocene?) deposits, has not yet been determined.

It appears very probable, from the investigations of Prof. L. C. Johnson, that the limits of the Tertiary formation extend considerably farther to the north than have generally been represented on the maps, the northward extension at Allenton being ten miles, six at Camden, and seventeen at Butler Springs[†]

Mississippi.

The Mississippi Tertiary formations, which cover by far the greater portion of the State, exhibit essentially three different facies: variously colored lignitiferous clays and sands—black, brown, blue, green, yellow, gray, and impure white; siliceous sandstones and claystones containing marine fossils; and limestones and calcareous marls, also with marine fossils. Lignitic clays occur intercalated throughout almost the entire series of deposits, and conversely, small estuarine deposits of marine shells occasionally appear in the true lignitic strata.[‡] All the subdivisions recognized in Alabama are also to be met with here, and as in that State, they follow each other in regular succession from north to south. The dip appears to be nearly conformable to that of the subjacent and eastwardly located Cretaceous deposits, being westward—about 4–5 feet per mile—in the northern part of the State, and southward—10–12 (average) feet per mile S. by W.—in the southern part.[§]

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[*] The "Buff Sands" of Winchell (*loc. cit.*, p. 89) probably falls into this group, but its exact position, or its correspondent, does not appear to be as yet definitely determined. It is seen to underlie the "Buhrstone," and is considered by Winchell to represent the absolute base of the Tertiary system of the State. At Black's Bluff, Wilcox Co., it is stated to repose directly on the subjacent Cretaceous limestone, but in a foot-note (p. 90), we are informed that, according to Tuomey, the characteristic fossil of this limestone, an *Ostrea*, is probably Tertiary.

[†] *Science*, vol. ii, p. 777 (Dec., 1883); iii, p. 32 (Jan., 1884).

[‡] Hilgard, "Agriculture and Geology of Mississippi," p. 107, 1860.

[§] Hilgard, Am. J. of Science, new ser., xliii, p. 36, 1867.

The following generalized section, slightly emended from Hilgard, is given upon the data furnished by that authority; the approximate thicknesses may be taken as *minima*, being often greatly exceeded.

1. Grand Gulf Group, or southern Lignite (Miocene ?)—variously colored sandstones, with small lignite beds, tree-palms, exogenous trees, *Arundinaceæ*.—150 feet.

2. Vicksburg beds (Oligocene—" Orbitoitic ").

    a. Crystalline limestones and blue marls, with *Ostrea Vicksburgensis*, *O. gigantea*, *Pecten Poulsoni*, *Cardium diversum*, *Arca Mississippiensis*, *Navicula Mississippiensis*, *N. lima*, *Crassatella Mississippiensis*, *Panopea oblongata*, *Fulgoraria Mississippiensis*, *Cypræa lintea*, *Dentalium Mississippiensis*, *Madrepora Mississippiensis*, *Orbitoides Mantelli*.—80 feet.

    b. Ferruginous rock of Red Bluff (" Red Bluff Group " of Hilgard, typically exposed in the bluffs of Chickasawhay River, near Red Bluff Station, Wayne Co.—the correspondent of the " Shell Bluff Group " of Conrad ?), with *Plagiostoma* (*Spondylus*) *dumosa*, *Cardita planicosta*, *C. rotunda*, *Rostellaria velata*, *Fulgoraria Mississippiensis*, *Mitra Mississippiensis*, *Cassidaria lintea*, *Conus sauridens*, *Busycon spiniger*, *Natica Vicksburgensis*, *Trochita trochiformis*, *Dentalium thalloides*, *Osteodes*, *Madrepora*, *Flabellum Wailesii*.—12 feet.

    c. Lignitic clay and lignite, as shown at the base of Vicksburg bluff.—20 feet.

3. Jackson beds (" Jacksonian "= Bartonian). White (often indurate) and blue marls, underlaid by lignitic clay and lignite, with *Zeuglodon macrospondylus*, *Cardita planicosta*, *Cardium Nicolleti*, *Leda multilineata*, *Corbula bicarinata*, *Rostellaria velata*, *Gastridium vetustum*, *Morio Petersoni*, *Voluta dumosa*, *Mitra Millingtoni*, *M. dumosa*, *Conus tortilis*, *Cypræa fenestralis*, *Trochita alta*, *Umbrella planulata*, *Flabellum Wailesii*, *Osteodes irroratus*.—80 feet.

4. Calcareous Claiborne (" Claibornian "—age of the " Calcaire Grossier ").—White (sometimes indurate) and blue marls, with the well-known Claiborne fossils. — ? feet.

5. Siliceous Claiborne ("Buhrstone"—Suessonian in part).—Sandstones and claystones with Claiborne fossils.— ? feet.

6. Lignitic or Northern Lignite (" Eo-Lignitic ")—Basal lignites, with interstratified clays and sands, containing marine fossils, and (Tippah) plant remains—*Quercus*, *Carya*, *Populus*, *Morus ?*, *Ficus*, *Laurus*, *Persea*, *Cornus*, *Olea*, *Rhamnus*, *Terminalia*, *Magnolia*, *Dryandroides ?*, *Rhus*.—425— ? feet.

Considerable uncertainty still exists relative to the age and position of the deposits constituting the Northern Lignite. Their local variability, uniformly moderate dip (or even horizontality), and dearth of fossil (animal) remains, combined with the circumstance that at only a few localities is a superposition of strata distinctly observable, render a positive determination difficult, if not impossible. That the region of the "Flatwoods" bordering the Cretaceous formation on the west, and extending to the northern boundary of the State, is of the same age as the formation occurring in Lauderdale and Neshoba Counties, which can be distinctly traced beneath the Siliceous Claiborne or "Buhrstone," there can be but little or no doubt, and, therefore, as far as the age of this section is concerned, nothing further need be said. But whether all the lignitic territory lying north of the marine Tertiary boundary, and occupying nearly the whole northern half of the State, belongs to the same geological period (Eo-Lignitic), as Hilgard appears disposed to believe,* may well be considered doubtful. On the contrary, it appears far more reasonable to suppose, seeing the position occupied by the outlier of the Siliceous Claiborne in Carroll, Holmes, Attala and Choctaw Counties (Shongalo, Valden, etc.), that the lignitiferous deposits, or at least a portion of them, of these counties, as well as of Yazoo, Madison and Leake, and possibly also of Yallabusha, belong to a much newer period, not improbably the Jacksonian. Hilgard clearly affirms that the marine outlier here referred to is as well *over* as *underlaid* by lignito-gypseous strata;† again in a boring made in the Jackson penitentiary well, and penetrating, as stated, to a depth of 470 feet, what would appear to be a continuation of the Shongalo (Siliceous Claiborne) deposits was struck at 450 feet, or 418 feet below the strata recognized to be of Jackson age. Granting the correct determination of the Shongalo deposit, it is evident that the 418 feet of lignitic clays passed through before the 20 foot shell-bed was reached, and regarding which "there can be little doubt that it, also, is of the Claiborne age," must represent something much newer than the basal lignites, and not improbably, as has already been suggested, the Jacksonian (at least in principal part).‡ Such a reference would be much more nearly in accord with the disposition of the Jackson beds in the adjoining State of Louisiana, where, according to Hopkins, the strata are also very largely lignitic, and where they occupy the greater part of the area included between the "Vicksburg" line and the Arkansas boundary.§ They doubtless extend for a considerable distance into Arkansas, largely entering into the formation of the Mississippi embayment, and meet their continuation on the other side of the river in the State of Mississippi.

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* "Agriculture and Geology of Mississippi," p. 109; Am. J. of Science, new ser., vol. xliii, p. 35.

† *Op. cit.*, pp. 122-3.

‡ Hilgard is not very explicit in his reference to the Shongalo deposit. While considering it an exponent of the Siliceous Claiborne in his geological reports of the State, in a later article, "On the Tertiary Formations of Mississippi and Alabama" (Am. J. of Science, xliii), the deposit in question is referred to the Lower Lignite on p. 34, and, again, on the following page we have mention of "the marine outlier of the Claiborne age, in Carroll and Attala."

§ Second Annual Report of the Geological Survey of Louisiana, p. 8, 1870.

Siliceous and Calcareous Claiborne.—There can be no question that the deposits we have recognized in Alabama and elsewhere as the "Buhrstone" and the "Claibornian" have their exact counterparts in Mississippi, and that these correspond in a general way with what Hilgard has designated the "Siliceous Claiborne" and the "Calcareous Claiborne" respectively. The former extends in a belt, some twenty miles wide, westward from the Alabama line nearly half across the State, reappearing as outliers in Carroll and Attala counties in the deposits of (near) Valden and Shongalo, to which reference has already been made in the discussion of the Northern Lignite. Among its commoner fossils are *Cardita planicosta*, *C. rotunda*, *Cardium Nicolleti*, *Ostrea divaricata*, *Pecten Lyelli*, and *Voluta petrosa*. From the locality of Enterprise, on the Chickasawhay River, Clarke County, situated on the line of contact of the "Siliceous" and "Calcareous Claibornes," as indicated by Hilgard, Mr. Conrad in 1865 described the following species of mollusca, claimed to be all new, "and distinct from those of any other locality from which fossils have been sent to the Academy;"[*] *Ostrea falciformis*, *Eburneopecten scintillatus*, *Arcoperna filosa*, *Nucula spheniopsis*, *Leda linifera*, *Axinæa* (*Pectunculus*) *inequistria*, *A. duplistria*, *Gouldia pygmæa*, *Crassatella producta*, *Protocardia lima*, *Cyclas curta*, *Sphærella bulla*, *Alveinus minuta*, *Cytherea securiformis*, *C. annexa*, *Tellina eburneopsis*, *T. albaria*, *Tellinella linifera*, *Corbula filosa*, *Doliopsis quinquecosta*, *Turritella perdita*, and *Mesalia? arenicola*.[†]

The true "Claibornian," consisting of blue marl and white marlstone, is but very feebly developed in the State, occupying a narrow strip, some thirty to forty miles in length, mainly in Clarke County, wedged in between the Buhrstone and Jackson. The fossils, in distinction to those of the corresponding Alabama deposit, are very imperfectly preserved, and in most cases specifically unrecognizable. The leading forms are: *Ostrea sellæformis*, *O. divaricata*, *Pecten Lyelli*, *Corbula gibbosa*, (*C. onisus*, Conr.; *C. rugosa*, Lam) and *Voluta petrosa*.

Jackson and Vicksburg.—The deposits of the Jackson and Vicksburg (Oligocene) periods occupy parallel bands passing across the State, disappearing in the west under the Mississippi alluvium. The most distinctive fossil of the former is the *Zeuglodon*, and of the latter *Orbitoides*, represented by two (*O. Mantelli*, *O. nupera*), or more species. Although by several observers, including Conrad, the fossils here indicated have been at various times referred to as occurring together in the same deposit, there can be but little question, as has been insisted upon by Hilgard, that either such reference has been based upon error, or that the interassociation, where it actually exists, dates to a period subsequent to that of the original deposition of the strata. At any rate, the painstaking investigations of the geologist last mentioned, have failed to reveal a single instance where an "Orbitoid has been found associated with either the Zeuglodon, or any of the characteristic fossils of the Jackson group."[*] From the neighborhood of Jackson, on the Pearl River, Conrad, in 1855, described the series of fossils which led him to institute a distinct division of the Eocene under the name of the "Jackson," and which he correctly located between the Claiborne and Vicksburg beds. Of the forty species described from this locality[†] thirty-four were considered to be peculiar, and only five—*Rostellaria velata*, *R. staminea*, *Scalaria nassula*, *Pseudoliva vetusta*, and *Endopachys expansum*—common to the Claiborne series. None of the Vicksburg fossils were considered to be represented. From the nature of his collection, which was a selected one, Conrad was led to infer that a far greater dissimilarity existed between the Jackson and Claiborne series on the one side, and the Jackson and Vicksburg on the other, than the actual facts warranted. In addition to the Claiborne fossils already mentioned as occurring in the Jackson beds, Prof. W. D. Moore[‡] mentions *Cardita planicosta* and *Cardita rotunda;* and as common to the Vicksburg series *Cardita rotunda*, *Navicula* (*Arca*) *lima*, *Cytherea sobrina*, *C. imitabilis*, *Mactra funerata*, *Psammobia lintea*, *Turbinella Wilsoni*, *Cypræa lintea*, *C. sphæroides*, *Natica Vicksburgensis*, and *Dentalium Mississippiense.* [§]

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[*] Am. Journ. of Conchology, i, pp. 137–41.

[†] Most of these are doubtless distinct, but it would be difficult, if not impossible, to distinguish between *Ostrea falciformis* and *O. divaricata*, *Nucula sphæniopsis* and *N. ovula*, and *Cytherea annexa* and *C. perovata*, common Claiborne fossils.

That a much closer connection exists between the deposits of the Jackson and Vicksburg series than was supposed by Conrad is proved by the character of the fossils occurring at or near Red Bluff Station, on the Chickasawhay River, in deposits lying intermediate between the Jackson and the typical Vicksburg, and considered by Hilgard to represent a subordinate group (Red Bluff Group) of the Vicksburg series. Of twenty specifically identified forms,[‖] Prof. Moore enumerates[¶] four,—*Cardita planicosta*, *Clavelithes humerosus ?*, *Rostellaria velata* and *Flabellum Wailesii*—as being common to the Jackson beds, and twelve to the Vicksburg—*Cardita rotunda*, *Cardium diversum*, *Fulgoraria Mississippiensis*, *Turbinella protracta*, *T. perexilis*, *Buccinum Mississippiensis*, *Cassidaria lintea*, *Mitra Mississippiensis*, *Busycon spiniger*, *Conus sauridens ?*, *Natica sigaretina* and *N. Vicksburgensis.*

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[*] A. J. Science, new ser,, xliii, p. 30.

[†] Proc. A. N. S., 1855, pp. 257–63 ; figures in Wailes' "Agriculture and Geology of Mississippi," 1854.

[‡] In Hilgard's Agriculture and Geology of Mississippi, 1860, p. 132.

[§] The author has not had the opportunity of verifying these determinations, and many others referred to by the various State Geologists. While accepting many of them, he feels inclined to express doubt in the case of others, seeing what difficulty attaches to correct identification from scanty materials, especially in the case of forms very imperfectly described and figured.

[‖] *Cardita planicosta*, *C. rotunda*, *Pecten nuperus*, *Cardium diversum*, *Rostellaria velata*, *Fulgoraria Mississippiensis*, *Clavelithes humerosus*, *Turbinella protracta*, *T. perexilis*, *Busycon spiniger*, *Buccinum Mississippiense*, *Cassidaria lintea*, *Mitra Missisippiensis*, *Conus sauridens ?*, *Cypræa sphæroides*, *Natica Vicksburgensis*, *N. sigaretina*, *Trochita trochiformis*, *Dentalium thalloides ?* and *Flabellum Wailesii ?*

[¶] *Loc. cit.*, p. 136.

The following section of the bluff at Vicksburg, on the Mississippi, whence Conrad obtained the fossils characteristic of the Vicksburg group, described in the Proceedings of the Academy of Natural Sciences of Philadelphia, for October, 1847 (and Journal of the same institution, vol. i), is given by Hilgard:

g. Calcareous silt with snails—Bluff formation.—10–20 feet.

f. Bluish and yellowish hardpan, often pebbles—Orange sand.—5–20 feet.

e. Alternating strata, 1 to 6 feet thick, of limestone and marl, containing the *Vicksburg fossils*, and some bands of non-effervescent gray sand and clay.—60–65 feet.

d. Black lignitic clay and gray sand, with *Ostrea gigantea*, *Corbula alta*, *Natica Mississippiensis*, *Cytherea sobrina*, *Madrepora Mississippiensis*.—5 feet.

c. Gray or black lignitic clays or sands, with iron pyrites; exuding salts and sulphuretted hydrogen.—25 feet.

b. Solid, lustrous lignite, with whitish cleavage planes.—3 feet.

a. White limestone of the Jackson group?—3 feet.

The white limestone *a* of the above section, which "is visible only at extraordinary low stages of water," appears to be of Jacksonian age, although conclusive paleontological evidence on this point is still wanting. Stratum *d*, containing *Ostrea gigantea* (=*O. Georgiana*), is that which has been identified by Conrad as corresponding to the Georgiana bed of Shell Bluff, on the Savannah River ("Shell Bluff Group"),* and which is erroneously stated to underlie the Jackson beds. The fossils associated with the large oyster in the Vicksburg Georgiana bed—*Corbula alta*, *Meretrix sobrina*, *Natica Mississippiensis*, *Natica Vicksburgensis*, *Fulgur nodulatum*, *Madrepora*, etc., show affinities alike with both the Jackson and Vicksburg faunas, and in this respect, as well as in stratigraphical position, would seem to point to a deposit, as has been urged by Hilgard, the correspondent of the "Red Bluff" series (as restricted to the Red Bluff group) on the Chickasawhay. At both localities the position is immediately below the Orbitoides rock, but at Red Bluff Station, the large oyster is wanting.

The relations of the Jackson and Vicksburg series of deposits to the geological scale have been discussed in the introductory portion of this paper.

GRAND GULF GROUP (MIOCENE?).—The newest Tertiary formations of Mississippi are constituted by the deposits of the "Grand Gulf Group" of Hilgard, which immediately succeed the Vicksburg beds to the south, and constitute the highest ridges in the southern portion of the State. "At their lines of contact, the Vicksburg and Grand Gulf rocks consist almost throughout of lignito-gypseous laminated clays, passing upwards into more sandy materials; they are not sensibly unconformable in place; but while the Vicksburg rocks show at all long exposures a distinct southward dip of some three to five degrees, the position of the Grand Gulf strata can rarely be shown to be otherwise than nearly or quite horizontal on the average; although in many cases faults or subsidences have caused them to dip, sometimes quite steeply, in almost any direction." *

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* A. J. Science, new ser., xli, p. 96.

Towards the sea-coast, the lithological transition into the post-Pliocene is about equally well marked as the transition into the older deposits in the north. The most remarkable circumstance connected with the Grand Gulf deposits is the almost total absence of zoogene fossils, whether land, marine or fresh-water. Up to 1881 it appears that only one solitary fragment of such fossil, determined to belong to a turtle, had been discovered;† and even the plant remains are in most cases unrecognizable, although the general regularity of the strata, as well as their lithological character, would seem to indicate that they were laid down under most stable conditions, or such as would be most conducive toward animal or plant preservation. Whether the temporary seclusion or cutting off of the Gulf from the Atlantic, as has been premised by Hilgard, was a, or the primary cause in bringing about this anomalous condition, still remains to be proved, and it further remains to be proved that any such seclusion actually took place.

Louisiana.

The general features of the Tertiary formations of this State are very much like those of Mississippi, and call for no special consideration. Only three divisions of the series, the Jackson, Vicksburg, and Grand Gulf, are officially recognized,‡ but it is not improbable that the Claiborne enters the northwest corner.

The exposures of the Vicksburg beds occupy a belt 10–15 miles or more § in width extending in a west–southwest direction from the Washita to the Sabine River. The distinctive fossils of the group are sufficiently abundant, and we find, as in Mississippi, a frequent association of *Orbitoides Mantelli*, *Ostrea Vickburgensis*, and *Pecten Poulsoni*. North of the Vicksburg line to the Arkansas boundary the strata are largely of a lignitic character, and indicate distinct alternations of marine and brackish-water conditions. They are collectively grouped under the Jackson period ("Mansfield Group," in part, of Hilgard), a position seemingly indicated by the character of the fossil remains. The remains of *Zeuglodon* have been found at Montgomery, in Grant parish, and at Grandview, on the Washita, a few miles below Columbia. Of about 150 species of invertebrate fossils collected from these deposits, it is claimed that at least nine occur, that in Mississippi are found in the Vicksburg beds alone, viz.: *Madrepora Mississippiensis*, *Orbitoides Mantelli*, *Avicula argentea*, *Terebra tantula*, *T. divisura*, *Pleurotoma porcellana*, *Pyrula* (2 species, undetermined), *Phorus humilis*, and *Ringicula Mississippiensis*. To this is also added *Ostrea Georgiana*. The occurrence here claimed, of *Orbitoides Mantelli* and *Ostrea Georgiana*, two forms whose horizons in Mississippi appear to be so trenchantly severed from the Jackson, would seem to throw some doubt upon the accuracy of the boundaries of the various formations as laid down.

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* Hilgard, A. J. Science, new ser., vol. xxii, p. 58.

† Hilgard, A. J. Science, new ser., vol. xxii, p. 59.

‡ Hopkins, "Second Annual Report of the Geological Survey of Louisiana," 1871.

§ Stated to be 30 miles by Hilgard, A. J. Science, new. ser., vol. xlviii, p. 339, 1869.

South of the Vicksburg line the deposits of the Grand Gulf group, destitute of fossil remains just as in Mississippi, extend across the State; they are succeeded to the south by the deposits of what Hilgard has termed the "Port Hudson Group" (Post-Pliocene; "Coast Pliocene" of Mississippi).

Arkansas.

About one-half of this State is occupied by the Tertiary formation, concerning whose development we are unfortunately provided with but very few reliable data. The various divisions have not yet been paleontologically defined, but probably the series includes the pre-Claibornian, the Claiborne, and the Jackson. The presence of the last is inferred from its position in the State of Louisiana, where, as it has been seen, it extends to the Arkansas boundary. Lignitic deposits occur largely throughout the Tertiary area, and while some of these doubtless represent the basal beds of the Eocene, as has been premised by Owen,*, others (of the S. E. section of the State) not improbably form the continuation of the Jackson lignites of Louisiana. Claiborne fossils—*Cardita planicosta*, *Cytherea* (probably *C. Nuttalli*), *Corbula oniscus*, *Pseudoliva vetusta*, *Turritella* (probably *T. carinata*), and *Voluta* (*V. Sayana?*)—have been obtained, among other localities, at "White Bluffs" on the Arkansas River (about latitude 34° 27′), and much the same assortment from the neighborhood of Madison, St Francis Co., on Crow creek.†

Texas.

The Tertiary formations of this State are as yet too imperfectly known to admit either of an absolute localization of the various boundary lines, or of an accurate subdivision into the minor geological groups. It may be safely assumed, however, from the geological conformation of the neighboring States, that all, or nearly all of the divisions ranging from the Eo-Lignitic to the Grand Gulf inclusive, are represented, and that the position occupied by these follow each other in regular succession, beginning with the oldest, from the interior coastward, with a general dip to the southeast or east. The geological notes on this region by Schott, Hall, and Conrad,‡ and of Shumard § and Buckley ‖ are exceedingly meagre and unsatisfactory, and give us barely more than a general idea as to where the Tertiary formation exists.

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* "Second Rept. Geol. Recon. of the Middle and Southern Counties of Arkansas," 1860.

† Owen, *op. cit.*, pp. 85, 152, and 417; Plate IX.

‡ Emory's Report, Mexican Boundary Survey, i, 1857.

§ First Report of Progress, Geol. and Agr. Survey of Texas, 1859.

‖ First Annual Report, 1874; Second Annual Report, 1876.

According to Dr. Loughridge, who, more than any other geologist, has closely investigated the outcrops of the different formations occurring throughout the State, the Cretaceo-Tertiary boundary line starts on the northeast from the Red River, at a point a few miles above Texarkana, on the Arkansas frontier, and taking a generally southwestern direction—passing at or near Clarksville (Red River Co.), Corsicana (Navarro Co.), Marlin (Falls Co.), Cameron (Milam Co.), Elgin (Bastrop Co.), Seguin (Guadeloupe Co.), and the northwest corner of Atascosa—crosses the Rio Grande at about the mouth of Las Moras Creek, a little south of the Pecos River, and to the north of Eagle Pass.*

The westerly deflection indicated as beginning a few miles south of San Antonio, and extending to the Rio Grande, can scarcely be said to be definitely proved as yet, although Loughridge affirms† that "the glauconitic sandstones, mentioned by Mr. Schott as occurring along the river [Rio Grande] from the Cretaceous rocks at the mouth of Las Moras Creek, north of Eagle Pass, southward to Roma, near Rio Grande City, are doubtless of Tertiary age." Further evidence is needed on this point, however, although some confirmation of the supposition is lent by the discovery of Tertiary fossils (*Cardita planicosta*, among others), in a locality, Arroya las Minas, situated between El Paso and Leon (where?)‡

Among the common Tertiary fossils occurring in Texas Buckley identifies§ *Ostrea sellæformis*, *Pecten Lyelli*, *Astarte Conradi* (= young of *Crassatella alta*), *Cardita planicosta*, and *Turritella carinata*; and there can be but little doubt, as claimed by Buckley, that the Eocene of Bastrop, Robertson, and Leon counties, and thence along the eastern border of the Cretaceous, northward to Red River County, belongs, if not mostly, at least in considerable part "to the lower Eocene, as seen at Claiborne, Alabama, and in Clark County, west of Claiborne." How much of it belongs to the true "Clabornian," still remains to be determined. Loughridge states that "the Claiborne group of white limestones and fossils has not been recognized in Texas;" the word "Claiborne" probably here stands for either "Jackson" or "Vicksburg," although there can be little, if any, question as to the existence of both of these formations, if nowhere else, at any rate along the Louisiana boundary.||

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* Cotton Production Report, pp. 18, 21, 1882, forming part of vol. v of the Tenth Census Reports.

† *Op. cit.*, p. 21.

‡ Conrad, in Emory's Report.

§ First Annual Report. p. 64.

|| The series of fossils described by Gabb in the Journal of the Academy of Natural Sciences (new ser., vol. iv), from Wheelock, Robertson County, and from Caldwell County, although comprising many forms quite distinct from any hitherto found in the "Claibornian" of either Mississippi or Alabama, appear by the general facies to belong more nearly to that group than to any other; yet among the number occur a few forms recalling a newer horizon. The author has been able to identify fragments obtained from an artesian well-boring in Palestine, Anderson County, about 50 miles southeast of the western outcrop of the Eocene, and from a depth beneath the surface of 540–610 feet (or 50–120 feet below the level of the Gulf), as belonging to *Cardita planicosta*, *Voluta Sayana*, and *Turritella carinata*. *Cardita planicosta*, or perhaps rather the form known as *C. densata*, associated with *Turritella carinata* and other Claiborne fossils, have also been detected by the author in limestone blocks from Laredo, on the Rio Grande, and he has described, as new forms, *Pleurotoma platysoma*, *Fusus* (*Strepsidura*) *Marnochi*, and *Terebra plicifera* from Atascosa County. It appears not improbable that the *Cardita planicosta* frequently referred to by geologists is in reality an allied species, *C. Moorei*.

Immediately to the south of the Eocene, according to Loughridge, a belt of sandstone, extending completely across the State, and probably referable to the Grand Gulf Group (Miocene?), makes its appearance. Beginning at the lower part of Sabine County, it outcrops on the Trinity River near Trinity Station, in the county of the same name, where it forms a bluff some 100 feet in thickness, near Chapel Hill and Burton in Washington County, at La Grange in Fayette, where it also forms a bluff 100 feet in height, and at various points in De Witt, Live Oak (passing near Oakville) and Duval counties, reaching the Rio Grande at Rio Grande City. Buckley also mentions the existence of "hard siliceous limestones and sandstones," referable to the newer Tertiary series, in Washington and Fayette counties, which evidently form part of the series described by Loughridge. They are stated to be practically devoid of fossils, only a few specimens of a bivalve (*Meretrix*) having been found near the centre of Washington County.[*] The formation here referred to is covered all along the coast line by the deposits of the Port Hudson Group (post-Pliocene).

Tennessee.

The Tertiary formations of Tennessee, occupying a tract some 60–75 miles in width in the western part of the State, consist of variously colored sands and clays, and lignitic deposits, from which traces of zoogene fossils are for the most part absent. Plant remains, on the other hand, are sufficiently abundant, clearly indicating the conditions under which the deposits in question were laid down.

The following subdivisions are recognized by Safford,[†] although the upper and lower groups are but provisionally indicated:

3. Bluff Lignite.
2. Orange Sand, or La Grange Group.
1. Porter's Creek Group (oldest).

The Porter's Creek Group, with a stated development of 200 or 300 feet, is doubtless, as is suggested by Safford, the northern extension of the "Flatwoods" of Mississippi, constituting the base of Hilgard's "Northern Lignite." Casts of shells occur in some of the sandy rocks, but their bad state of preservation precludes the possibility of their determination. The belt of surface occupied by this group is along the line of the Memphis and Charleston Railroad about eight miles wide, narrowing towards the north. The outcrop of the Orange Sand, whose thickness is assumed to be about 600 feet, covers a tract some 40 miles in width, the beds dipping at a slight angle to the west.[‡] Vegetable remains belonging to fourteen[§] or more species of plants have been described from the deposits of this group by Lesquereux, by whom they were considered to indicate a horizon more nearly Miocene than Eocene, but there can be but little doubt from the position of the beds containing them that they belong to the same period to which the greater part of the northern Mississippi lignite itself belongs—the lower Eocene. The Bluff Lignite, underlying the Quarternary gravels of the Mississippi Bluffs, consist in large part of a series of interstratified sands and clays, "characterized by the presence of well-marked beds of lignite." Its development appears to be at least 100 feet.

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[*] Buckley, First Annual Report, p. 63. [†] "Geology of Tennessee," 1869, p. 422, *et seq.* [‡] Safford, *op. cit.*, p. 425.

[§] *Quercus crassinervis. Q. Saffordi, Q. myrtifolia?, Q. Lyelli, Prunus Caroliniana, Fagus ferruginea, Elæagnus inæqualis, Andromeda vaccinifolia* (form related to), *A. dubia, Sapotacites Americanus, Salix? densinervis, Salix Worthenii, Cænothus Meigsii, Juglans Saffordiana.*

Illinois.

The Tertiary deposits of Arkansas and Tennessee are continued through the south-east and southwest extremities respectively of the States of Missouri and Kentucky into Illinois, where they form the head of the Mississippi embayment. The series, represented by variously colored sands and clays, and ferruginous conglomerates, has thus far been identified only in the southern part of the State (with a principal development in Pulaski County), but not improbably, as has been suggested by Worthen, marine or fluvio-marine deposits of the same age may occur considerably higher up the Mississippi valley.[*] A green marly sand, resembling in its lithological characters the Cretaceous greensand of New Jersey, constitutes a marked feature of the formation in Pulaski County, and from it have been obtained casts of fossils pertaining to the genera *Cucullœa* and *Turritella*.[†]

A thin bed of lignite is stated to underlie the formation along the edge of the Ohio at Caledonia, constituting in that vicinity the lowest visible member of the series.

NOTE *a*.—Since the preparation of the foregoing article, I am informed by Prof. Suess, of Vienna, that the lower limestone beds of the island of Malta, which were originally referred by Fuchs to the "Aquitanian" (Oligocene), and as the partial equivalents of the Sotzka beds of the Vienna basin, belong in reality to the "First Mediterranean." If this be the case, then the *Orbitoides Mantelli* beds of the island represent a newer horizon —lower Miocene—than they do in our own country and the West Indies. In material recently received from Florida I find great quantities of *Orbitoides ephippium* associated with the other forms.

b.—In the "Virginias," for February, 1882, and October, 1882, will be found detailed accounts, by Prof. W. M. Fontane and the late Prof. W. B. Rogers, of the 907-foot artesian boring at Fort Monroe, on the peninsula, about 6 miles to the east of Newport News.

⁂ In the accompanying map the Cretaceous exposures in the Tertiary area (North Carolina, South Carolina) have been, for convenience, omitted; likewise the exposures of the Eocene in the Miocene tracts.

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[*] "Geological Survey of Illinois," i, p. 46, 1866.

[†] Worthen, *op. cit.*, p. 45. The forms are here considered to be specifically unidentifiable, but on p. 423, the *Turritella* is referred, although with doubt, to *T. Mortoni*, a distinctively lower Eocene fossil.

II.

ON THE RELATIVE AGES AND CLASSIFICATION OF THE POST-EOCENE TERTIARY DEPOSITS OF THE ATLANTIC SLOPE.

It may appear surprising that for a period of nearly fifty years after the study of the American Tertiary formations was first systematically attempted, there should still have existed among geologists widely varying views, not only relative to the positions occupied by a considerable proportion of the deposits in question in the geological scale, but also relative to the positions occupied by these deposits in respect of each other. Yet such has been the case, and it may still be said to be the case at the present time. The existence of post-Eocene deposits along the Atlantic border of the United States has long since been recognized, and their contained fossil remains investigated and delineated by paleontologists of more or less ability. While the opinions expressed by certain geologists as to the age of at least some of these deposits may be said to have been substantially correct, yet in face of the conflicting views of other geologists of no less experience and prominence, which were set forth and maintained with a decisiveness unwarranted by the character of the research upon which they were based, it may be stated that the general outcome of our knowledge respecting the stratigraphy of the deposits here referred to is simply, that they hold a position somewhere intermediate between the Eocene and the post-Pliocene series.

The post-Eocene Tertiary deposits have their greatest development, and have been most carefully investigated in the States of Maryland, Virginia, North and South Carolina.. In the frequently expressed opinion of Mr. Conrad they represented over the entire area here indicated one geological formation, which that geologist generally asserted to be the Miocene, but which, at the same time, he not unfrequently considered to be the equivalent of the British Crag, a formation now universally regarded as being of Pliocene age.

No attempt appears to have been made to determine whether the deposits were referable to one or several faunal horizons, and the organic remains obtained from them were simply classified as belonging to the Miocene or "medial Tertiary" period. The circumstance that in North Carolina the proportion of recent to extinct forms among the imbedded remains was greater than in either Virginia or Maryland did not escape the notice of the observer mentioned, but yet he did not hesitate to conclude (Kerr, Geological Survey of North Carolina, Appendix, p. 25, 1875) that his Miocene strata represented "one contemporaneous sea bottom, holding living individuals of certain species throughout its entire length, and which is characterized by some of its species closely resembling existing ones, but many more having no affinity with American shells." How many of the fossil species were by Mr. Conrad considered to be identical with recent forms it is impossible to determine with any amount of exactitude, since the opinions of that geologist bearing upon this point appear not to have been fixed, and to have fluctuated extensively within very brief intervals of time. Thus, while in 1838 (Fossils of the Medial Tertiary Formations, Introduction, p. xvi), it is asserted that of about 200 described species 19 (or less than 10 per cent.) are still among the living fauna, in 1843 (Proc. Phil. Acad. Nat. Sciences, i, p. 328), the number of recent forms is said to be 43 out of a total of 328 described; in 1862, on the other hand, referring to the South Carolina deposits, where the percentage of recent forms had been claimed to be greater than in either of the other three States, Mr. Conrad maintains that "it may be that all the species are extinct" (Proc. Acad. Nat. Sciences, xiv, p. 559). It is further stated (*loc. cit.*) that of the entire number, 581, of Miocene shells of the Atlantic slope, the number of forms that could be considered as doubtfully identical with recent species was not more than 30 (or about 5 per cent.). The faunal relations existing between these so-called "medial Tertiary" deposits and the deposits of the British Crag and the faluns of the Loire, at that time supposed to be of nearly equivalent age, were likewise pointed out by Lyell (Journ. Geol. Society, i, p. 413, *et seq.*), who also did not fail to notice that in North Carolina "the recent species bore a larger proportion than usual to the extinct" *loc. cit.*, p. 418). But this geologist, with his characteristic acuteness, further remarks: "As, however, it would be very rash to assume that all the Miocene deposits of the United States, especially in countries as far apart as Maryland and South Carolina, were of strictly contemporaneous origin, the fossil-faunas of each region should be carefully distinguished and considered separately" (p. 418). Of 147 species of mollusca gathered by Mr. Lyell himself, and which were subsequently studied with the assistance of Mr. Sowerby, twenty-three (or 15½ per cent.) were considered to be identical with recent forms (p. 419). In the later editions of the "Elements of Geology" (1871, 1874) the deposits in question are referred to the Pliocene and Miocene, but no clearly defined statement is given as to which belonged to the one age, and which to the other.

From a more careful examination of the South Carolina region than had previously been made, Mr. Tuomey arrived at the conclusion (Geology of South Carolina, 1848), that the post-Eocene Tertiary deposits of that State belonged to the Pliocene, and not to the Miocene period, and that, consequently, they were not contemporaneous with the deposits (in Virginia) which had now been firmly recognized as typically representing the Miocene of the eastern United States. Of about 170 species of mollusca contained by them, somewhat more than 80 (or nearly 50 per cent.) were considered to be still living along the Atlantic and Gulf coasts (*op. cit.*, pp. 206–208). The Pliocene age of these deposits was maintained by Professors Tuomey and Holmes in their "Pleiocene Fossils of South Carolina" (1857), where also the deposits of North Carolina (Miocene of Emmons, North Carolina Geological Survey 1858) are referred to the same period. Of 203 species of described invertebrate remains (mollusks, echinoderms, and corals), 85 (or 42 per cent.) were considered to have living analogues (*op. cit.*, Introduction, ix). The determinations of Tuomey and Holmes for both the South and North Carolina deposits are accepted by Dana for the several editions (1863, 1875, 1880) of his "Manual of Geology," where the "Yorktown" period is made to include the post-Eocene Tertiary beds of Virginia, Maryland, New Jersey, and Martha's Vineyard, and the "Sumter" period, the similar beds of North and South Carolina. In the "Check List of the Invertebrate Fossils of North America," prepared (doubtless from data furnished by Conrad) in 1864 by Mr. Meek for the Smithsonian Institution (Miscellaneous Collections, vii), all the non-Eocene or Oligocene Tertiary fossils of the eastern United States are classed as belonging to the Miocene period; and finally, Prof. C. H. Hitchcock, in the "Geological Map of the United States" (1881), accepts the Miocene determination for the age of the North and South Carolina deposits, as likewise for the Virginia deposits, and those of the peninsula of Maryland. The deposits of the Maryland east-shore, of Delaware, and the greater portion of those in New Jersey which lie to the east and south of the "upper marl bed," are embraced within the Pliocene (newer Tertiary).

In order to facilitate the solution of the stratigraphical problem herein involved, the following faunal lists of the several States (Maryland, Virginia, North and South Carolina) have been prepared, and comparisons between them instituted. The utterly desultory and careless manner in which a very considerable portion of the paleontology of the region referred to has been worked up, has rendered their preparation a matter of great difficulty, and, indeed, if absolute accuracy is concerned, a well-nigh impossibility. Not only have species been referred to several distinct genera (and families), and catalogued under their respective generic names independently of each other, but in several instances the identical specimen has been figured and redescribed under two or more forms; species, again, originally described from the deposits of one State, have been subsequently credited (and to the exclusion of the first-named locality) to the deposits of another State. Defective illustrations, and in very many cases the absence of illustrations altogether, have still further increased the difficulties, especially where the described specimens themselves are wanting, or where through unsatisfactory diagnoses their specific (or even generic!) identification is rendered hopeless. Many of the forms here included are therefore taken on faith, and many will doubtless have to be excluded when fresh material is gathered in the field and re-studied. *Per contra*, many forms, seemingly doubtful, have been excluded, which may possibly have to be reinstated on further examination. Where it has been possible (and this has been the case for most of the forms) the original descriptions of the species have been referred to, and the localities of their occurrence there indicated have been those which have been noted; species said to occur in the deposits of several States have been traced back for re-descriptions, or to papers bearing specially on the paleontology of those States, but very little reliance being placed on general enumerations of distribution. By this means it has been hoped to render the lists as complete and free from error as could reasonably be made possible, and while, doubtless, various modifications will eventually have to be introduced, it is confidently believed by the author that they so far represent the true state of matters as to permit of positive conclusions being drawn from them.

The comparisons here instituted between the molluscan faunas from the deposits of the several States have been made separately for the lamellibranchiata and the gasteropoda; and it may be stated at the outset that the results obtained from the independent examination of these two groups of organisms have been found singularly confirmative of each other. The letters following the name of a species denote that the form is also found in the State or States indicated by their respective characters; but it must be noted in the case of the gasteropoda, that comparisons, as indicated by such initial characters, are made between certain States only, and, therefore, it is not to be concluded from the examination of a single list, that a given form there designated is necessarily wanting in a State whose characters are not indicated in that list. Thus, in the South Carolina list only the North Carolina species are specially indicated, although several of these last, and others, are also found in the Virginia and Maryland deposits; so, again, in the Virginia list, no special reference is made to the Maryland forms.

TABLES OF THE POST-EOCENE TERTIARY LAMELLIBRANCHIATA OF SOUTH CAROLINA AND NORTH CAROLINA.

South Carolina.

Anomia ephippium,	N. C.	Arca hians = A. propatula?	Va.
Placunomia plicata.		" incile,	N. C.; Va.; M.
Ostrea Virginiana,	N. C.; Va.; M.	" costata,	N. C.
" Ravenelliana.		" centenaria,	N. C.; Va.; M.
Chama corticosa,	N. C.; Va.	" rustica.	
" arcinella,	N. C.	" lienosa = A. Floridana,	N. C.
" congregata,	N. C.; Va.	" scalaris,	N. C.; Va.
Plicatula marginata,	N. C.; Va.; M.	" incongrua.	
Janira hemicycla.		" pexata.	
" affinis.		" plicatura,	N. C.; Va.; M.
Pecten Mortoni,	N. C.	(A. improcera.)	
" eboreus,	N. C.; Va.	(A. æquicostata.)	
" comparilis,	N. C.	(A. transversa.)	
" Peedeensis,	N. C.	Pectunculus subovatus,	N. C.; Va.; M.
" septemnarius,	Va.; M.	" lentiformis,	N. C.; Va.; M.
Mytilus inflatus.		" passus,	N. C.; Va.
" incrassatus,	N. C.	" quinquerugatus,	N. C.

Pectunculus lævis.	
" aratus,	N. C.
" transversus.	
Yoldia limatula,	N. C.; Va.; M.
Leda acuta,	N. C.; M.
Nucula proxima = N. obliqua,	N. C.; Va.; M.
Lucina contracta = L. filosa,	N. C.; Va.; M.
" anodonta,	N. C.; Va ; M.
" Pennsylvanica,	N. C.
" radians = L. Antillarum,	N. C.
" squamosa = L. pecten,	N. C.; Va.
" cribraria,	M.
" divaricata,	N. C.; Va., M.
" costata.	
" crenulata,	N. C.; Va.; M.
" multilineata,	N. C.
" trisulcata.	
Cardium Carolinense = C. magnum ?	N. C.
" muricatum,	N. C.
" sublineatum,	N. C.; Va.
Cardita arata,	N. C.; Va.; M.
" granulata,	N. C.; Va.; M.
" tridentata,	N. C. ?
" carinata,	N. C.
" perplana,	N. C.
" abbreviata,	N. C.
Astarte undulata,	N. C.; Va.; M.
" bella,	N. C.
Gouldia lunulata,	N. C.; Va.
Crassatella undulata,	N. C.; Va.; M.
" Gibbesii,	N. C.
Cyrena densata,	N. C.; Va.
Rangia clathrodonta,	N. C.; Va.
Venus Rileyi,	N. C.; M.
" mercenaria,	N. C.; Va.?; M.?
" athleta,	N. C.
Venus tridacnoides,	N. C.; Va.; M.
" permagna,	Va.; M.?
Cytherea subnasuta.	M.
" reposta,	N. C.; Va.
" Sayana,	N. C.; Va.; M.
" cribraria = C. punctulata ?	N. C.
" cancellata.	
Circe metastria,	N. C.; Va.
Artemis intermedia,	N. C.
Petricola pholadiformis.	
Tellina biplicata,	N. C.; M.
" alternata,	N. C.
" lusoria,	N. C.; Va.
" polita,	N. C.
Strigilla flexuosa,	N. C.
Psammocola Pleiocena.	
Cumingia tellinoides,	Va.
Amphidesma carinata,	M.
" equalis,	N. C.
" orbiculata.	
" æquata,	N. C.
Donax variabilis,	N. C.?
Standella fragilis,	N. C.?
Mactra similis = M. solidissima,	N. C.
" lateralis,	N. C.
" congesta,	N. C.; Va.
Pandora trilineata,	N. C.?; Va.
Panopæa reflexa,	N. C.; Va.; M.
Corbula cuneata,	N. C.; M.
" inequale,	Va.; M.
Pholadomya abrupta,	N. C.; Va.; M.
Solecurtus Caribæus,	N. C.
Solen ensis,	N. C.; M.
Pholas costata,	N. C.; Va.?; M.?
" oblongata,	N. C.
" Memmingeri,	N. C.

North Carolina.

Anomia ephippium,	S. C.
Ostrea Virginiana,	S. C.; Va.; M.
Pecten comparilis,	S. C.
" eboreus,	S. C.; Va.
" Clintonius = P. Magellanicus,	Va.; M.
" Peedeensis,	S. C.
" Mortoni,	S. C.
" Jeffersonius,	Va.; M.
" Madisonius,	Va.; M.
" vicenarius.	
Plicatula marginata,	S. C.; Va.; M.
Mytilus incrassatus,	S. C.
Crenella, sp. ?	
Chama arcinella,	S. C.
" corticosa,	S. C.; Va.
" congregata,	S. C.; Va.
" striata.	
Arca lienosa = A. Floridana,	S. C.
" limula,	Va.
" scalaris,	S. C., Va.
" incile,	S. C.; Va.; M.
" centenaria,	S. C.; Va.; M.
" cælata,	S. C.
" idonea,	Va.; M.

Arca plicatura,	S. C.; Va.; M.
" brevidesma.	
" subsinuata.	
Pectunculus subovatus,	S. C.; Va.; M.
" lentiformis,	S. C.; Va.; M.
" aratus,	S. C.
" tricenarius.	
" passus,	S. C. Va.
" Carolinensis.	
" quinquerugatus,	S. C.
Leda acuta,	S. C.; M.
Yoldia limatula,	S. C.; Va.; M.
Nucula proxima = N. obliqua,	S. C.; Va.; M.
Lucina Pennsylvanica,	S. C.
" contracta = L. filosa,	S. C.; Va.; M.
" crenulata,	S. C ; Va.; M.
" anodonta,	S. C.; Va.; M.
" radians = L. Antillarum,	S. C.
" divaricata,	S. C.; Va.; M.
" multilineata,	S. C.
" squamosa = L. pecten,	S. C.; Va.
Loripes elevata.	
Mysia Americana (acclinis).	
Cardium Carolinense = C. magnum?	S. C.
" muricatum,	S. C.
" sublineatum,	S. C.; Va.
Glycocardia granula.	
Isocardia fraterna,	Va.; M.
Cardita arata,	S. C.; Va.; M.
" perplana,	S. C.
" granulata,	S. C.; Va.; M.
" abbreviata,	S. C.
" tridentata,	S. C.
" carinata,	S. C.
Pleuromeris decemcostata.	
Astarte bella,	S. C.
" clathra.	
" undulata,	S. C.; Va.; M.
" curta.	
Gouldia lunulata,	S. C.; Va.
Crassatella undulata,	S. C.; Va.; M.
Crassatella Gibbsii,	S. C.
" Marylandica,	M.
" melina.	Va.; M.
Verticordia, sp.?	
Cyrena densata,	S. C.; Va.
Rangia clathrodonta,	S. C.; Va.
Venus mercenaria,	S. C.; Va.?; M.?
" tridacnoides,	S. C.; Va.; M.
" Rileyi,	S. C.; M.
" alveata,	Va.; M.
" latilirata,	Va.
" athleta,	S. C.
Cytherea Sayana,	S. C.; Va.; M.
" reposta,	S. C.; Va.
" cribraria = C. punctulata?	S. C.
Circe metastria,	S. C.; Va.
Artemis transversus = A. intermedia?	S. C.
" acetabulum,	Va.; M.
Telina biplicata,	S. C.; M.
" lusoria,	S. C.; Va.
" alternata,	S. C.
" polita,	S. C.
" arctata.	
Strigilla flexuosa,	S. C.
Amphidesma æquata,	S. C.
" equalis,	S. C.
Mulinia variabilis.	
Mactra congesta,	S. C.; Va.
" oblongata = Standella fragilis?	S. C.?
" lateralis,	S. C.
" similis = M. solidissima,	S. C.
Donax, sp.?	
Pandora trilineata?	S. C.; Va.
Panopæa reflexa,	S. C.; Va.; M.
Corbula cuneata,	S. C.; M.
Pholadomya abrupta,	S. C.; Va.; M.
Solecurtus Caribæus,	S. C.
Solen ensis,	S. C.; M.
Pholas costata,	S. C.; Va.?; M.?
" oblongata,	S. C.
" Memmingeri,	S. C.

An examination of the preceding lists shows that of about 103 forms of lamellibranchiate mollusks found in the South Carolina deposits no less than 74–78 (or about 74 per cent.) are also found in the deposits of North Carolina; these last being represented by an almost equal number (106) of specific forms, the relative percentages of those common to the two States will necessarily be nearly identical. We have thus *prima facie* evidence that the deposits characterized by these remains belong very nearly, if not absolutely, to the same geological horizon. On the other hand, of the

South Carolina forms at most only 43 (or 42 per cent.) are indicated as being found in Virginia, and a still smaller number, 34 (or 33 per cent.), in Maryland. We have here, therefore, strong evidence tending to prove that the deposits of the last mentioned States represent a horizon different from those indicated by the deposits of South Carolina. Similarly, of the 106 North Carolina species, at most only 48 (or 46 per cent.) are common to Virginia, and 36 (or 34 per cent.) to Maryland, a result that strikingly confirms the conclusion that has just been drawn.

Passing now to the examination of the Virginia lamellibranchiates, we find, as is shown in the following table, a total of about 109 specific forms:

Virginia.

Anomia Ruffini.	
Ostrea sculpturata.	
" disparilis.	
" Virginiana,	S. C.; N. C.; M.
" subfalcata.	
Pecten fraternus.	
" Rogersi.	
" biformis.	
" Virginianus.	
" tricenarius.	
" Jeffersonius,	N. C.; M.
" dispalatus.	
" septemnarius,	S. C.; M.
" Clintonius = P. Magellanicus.	N. C.; M.
" eboreus,	S. C.; N. C.
" Madisonius,	N. C.; M.
" decemnarius.	
Plicatula marginata,	S. C.; N. C.; M.
Perna maxillata,	M.
Crenella æquilatera.	
Arca centenaria,	S. C.; N. C.; M.
" incile,	S. C.; N. C.; M.
" idonea,	N. C.; M.
" protracta = A. lienosa?	S. C.?; N. C.?
" scalaris,	S. C.; N. C.
" propatula (hians)	S. C.
" limula,	N. C.
" plicatura,	S. C.; N. C.; M.
Pectunculus subovatus,	S. C.; N. C.; M.
" tumulus.	
" passus,	S. C.; N. C.
" lentiformis,	S. C.; N. C.; M.
Yoldia limatula,	S. C.; N. C.; M.
Nucula obliqua (N. proxima),	S. C.; N. C., M.
Lucina squamosa = L. pecten,	S. C.; N. C.
" crenulata,	S. C.; N. C.; M.
" divaricata,	S. C.; N. C.; M.
Lucina anodonta,	S. C.; N. C.; M.
" contracta = L. filosa,	S. C.; N. C.; M.
" Leana (lens).	
" edentula.	
Mysia Americana,	N. C.
Kellia lævis.	
" striata.	
Erycinella ovalis.	
Sphærella subvexa.	
Chama corticosa,	S. C.; N. C.
" congregata,	S. C.; N. C.
Cardium Virginianum.	
" laqueatum,	M.
" sublineatum,	S. C.; N. C.
Isocardia fraterna,	N. C.; M.
Cardita arata,	S. C.; N. C.; M.
" granulata,	S. C.; N. C.; M.
Astarte undulata,	S. C.; N. C.; M.
" (Euloxa) latisulcata.	
" arata.	
" Coheni.	
" concentrica.	
" lineolata.	
" symmetrica.	
Gouldia lunulata,	S. C.; N. C.
Crassatella undulata,	S. C.; N. C.; M.
" melina,	N. C.; M.
Cyrena densata,	S. C.; N. C.
Rangia clathrodonta,	S. C.; N. C.
Venus capax.	
" ascia?	
" latilirata,	N. C.
" mercenaria?	S. C.; M.?
" permagna,	S. C.; M,?
" alveata,	N. C.; M.
" Rileyi,	S. C.; N. C.; M.
" tridacnoides,	S. C.; N. C.; M.

Circe metastria,	S. C.; N. C.
Cytherea obovata.	
" reposta,	S. C.; N. C.
" Sayana,	S. C.; N. C.; M.
" densata.	
" Virginica.	
" cortinaria.	
Artemis acetabulum,	N. C.; M.
Petricola centenaria,	M.
Tellina declivis.	
" egena.	
" lusoria,	S. C.; N. C.
Abra subreflexa.	
Cumingia tellinoides,	S. C.
Mactra modicella.	
" delumbis,	M.
" congesta,	S. C.; N. C.
" triquetra.	
Thracia transversa.	
Anatina antiqua.	
Pandora crassidens = P. trilineata.	S. C.; N. C.
" arenosa = P. trilineata?	
Mya producta,	M.
" corpulenta.	
Paramya subovata.	
Corbula inequale,	S. C.; M.
Pholadomya abrupta,	S. C.; N. C.; M.
Panopæa reflexa,	S. C.; N. C.; M.
Solen magnodentatus?	
Saxicava bilineata = S. rugosa,	M.
Saxicava pectorosa.	
Pholas (?) rhomboidea.	
" acuminata = P. costata?	S. C.? N. C.? M.?
Teredo fistula.	
Gastrochæna ligula.	

NOTE.—The following species described by H. C. Lea (Trans. Amer. Philos. Soc., ix, new series), based upon young shells, or upon such as barely admit of characterization, have been omitted from the enumeration:—*Avicula multangula*, *Anatina tellinoides*, *Cytherea elevata*, *C. spherica*, *Leda acutidens*, *L. carinata*, *Modiola spinigera*, *Mya reflexa*, *Nucula dolabella*, *N. diaphana*, *Panopæa dubia*, *Petricola compressa*, *Pecten micropleura*, *P. tenuis*, *Plicatula rudis*, *Psammobia lucinoides*, *Teredo calamus*.

Of these 109 species, as has already been stated, at most only 43 (or 40 per cent.) are common to South Carolina, and about 48 (or 44 per cent.) to North Carolina. Compared with the Maryland deposits the proportion of forms common to the two States is found to be not very different from the proportion just indicated, or about 38 per cent. (about 41 species).[*]

From the so-called "medial Tertiary" of Maryland there have thus far been described about 98 species of acephalous mollusks:—

Maryland.—Newer Group.

Amphidesma carinata,	S. C.
" subovata.	
Arca idonea,	N. C.; Va.
" incile,	S. C.; Va.
" centenaria,	S. C.; Va.
" improcera,	S. C.; N. C.; Va.
Artemis acetabulum,	N. C.; Va.
Astarte vicina?	
" cuneiformis.	
" perplana.	
" obruta.	
" undulata,	S. C.; N. C.; Va.
Cardita arata,	S. C.; N. C.; Va.
" protracta,	
Cardita granulata,	S. C.; N. C.; Va.
Cardium laqueatum,	Va.
Corbula cuneata,	S. C.; N. C.
" idonea.	
" inequalis,	S. C.; Va.
Crassatella Marylandica,	N. C.
" undulata,	S. C.; N. C.; Va.
Cytherea Sayana,	S. C.; N. C.; Va.
" albaria.	
" Marylandica.	
Cytherea staminea.	
Isocardia fraterna,	N. C.; Va.
Leda acuta,	S. C.; N. C.
" concentrica.	

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[*] The Maryland deposits, in the comparisons thus far, have for convenience been taken to represent one geological horizon; their division into two groups, and the relations of each of these groups with the deposits of the several other States, are specially considered further on.

Yoldia lævis = Y. limatula,	S. C.; N. C.; Va.
Nucula proxima = N. obliqua,	S. C.; N. C.; Va.
Lepton (?) mactroides.	
Lucina anodonta,	S. C.; N. C.; Va.
" subobliqua,	
" cribraria,	S. C.
" contracta = L. filosa,	S. C.; N. C.; Va.
" divaricata,	S. C.; N. C.; Va.
Mactra ponderosa.	
" fragosa.	
" subcuneata.	
" delumbis,	Va.
Mya producta,	Va.
Ostrea Virginica,	S. C.; N. C.; Va.
Panopæa Americana.	
" reflexa,	S. C.; N. C.; Va.
" porrecta.	
Pecten Madisonius.	N. C.; Va.
" Jeffersonius,	N. C.; Va.
Pecten Clintonius,	N. C.; Va.
" septemnarius,	S. C.; Va.
Pectunculus subovatus,	S. C.; N. C.; Va.
Petricolia centenaria,	Va.
Plicatula marginata,	S. C.; N. C.; Va.
Pholadomya abrupta,	S. C.; N. C.; Va.
Pholas ovalis = P. costata?	S. C.? N. C.? Va.?
Saxicava rugosa,	Va.
Solen ensis,	S. C.; N. C.
Tellina æquistriata,	
" biplicata,	S. C.; N. C.
Venus tetrica.	
" permagna?	S. C.; Va.
" alveata,	N. C.; Va.
" inoceriformis.	
" tridacnoides,	S. C.; N. C.; Va.
" mercenaria?	S C.; N. C.; Va.?
" Rileyi,	S. C.; N. C.; Va.
" cuneata.	

Maryland.—Older Group.

Arca callipleura,	
" subrostrata,	
" Marylandica,	
" triquetra,	
Artemis acetabulum,	N. C.; Va.
Astarte exaltata.	
" varians.	
Cardium craticuloides.	
" leptopleura.	
Corbula idonea.	
" elevata.	
Crassatella melina,	N. C.; Va.
" turgidula,	
Cytherea subnasuta,	S. C.
Isocardia Markoei.	
Leda liciata.	
Lima papyria.	
Lucina Foremani.	
" subplana.	
" crenulata,	S. C.; N. C.; Va.
Modiola Ducatellii,	
Mytilus incurva,	
Pecten Humphreysianus.	
" Madisonius,	N. C.; Va.
Pectunculus parilis,	
" lentiformis,	S. C.; N. C.; Va.
Perna maxillata,	Va.
Pholas costata? (P. ovalis.)	S. C.; N. C.; Va.
Panopæa porrecta,	
Tellina lenis,	
Venus Mortoni? (V. cuneata?)	
" alveata,	N. C.; Va.

NOTE.—Several species formerly credited to this State have been intentionally omitted, there not being sufficient evidence to prove their occurrence there.

Of these 98 about 34 (35 per cent.) are common to South Carolina, 36 to North Carolina (37 per cent.), and 41 to Virginia (42 per cent.). It has, however, been shown in a previous paper (Heilprin, Proc. Acad. Nat. Sciences, 1880, p 20 *et seq.*) that the Maryland deposits actually represent two distinct horizons—respectively designated (temporarily) as the "newer" and "older" groups—and, therefore, in order to have a proper appreciation of the value of these proportions it will be necessary to consider the two divisions in their relations to the several States separately.

The deposits of the "newer" group, as will be seen from the preceding enumeration, contain 66 species, and those of the "older" group, 32 species. Of the former about 33 (50 per cent.), and a nearly equal number, 32 (49 per cent.), are common respectively to South and North Carolina, whereas of the latter, only 4 (13 per cent.)

are found in the first-named State, and 7 (22 per cent.), in the second.* While the "newer" group shows a considerably higher percentage of forms common to both South and North Carolina than the deposits of the State treated as a whole, this percentage is still less than that which might naturally be expected to exist between formations (removed by about equal distances) representing an equivalent age. The rational inference is, therefore, that the deposits in question are not of contemporaneous formation. Compared with the deposits of Virginia the fauna of the "newer" group shows a somewhat more decided relation than to the deposits of the States just mentioned, for we now find the percentage of common forms increased to 56 (37 species). But even with this figure it would be rash to insist upon an equivalency being proved. Nor is the relation of the "older" group to the Virginian formation much more pronounced than it is to the North Carolinian, but no special deductions from agreements or differences of percentages can be made in this instance, since the number of both common and restricted forms is very limited.

The conclusions reached from the examination thus far of the lamellibranchiate fauna are: That the South and North Carolina formations represent one and the same horizon, and one distinct from the horizon or horizons indicated by the Virginia and Maryland formations. It now remains to be determined what support this conclusion receives from the study of the fossil faunas in their relation to the faunas of existing seas, and to ascertain through the same means what relation the various horizons bear toward each other.

Species still living found fossil in the South Carolina deposits.†

Anomia ephippium (A. Conradi).
? Placunomia plicata.
Ostrea Virginiana.
Chama arcinella.
Arca lienosa = A. Floridana.
" incongrua.
? " pexata.
Yoldia limatula (Leda lævis).
Leda acuta.
Nucula proxima = N. obliqua.
Lucina contracta = L. filosa.
" Pennsylvanica.
" radians = L. Antillarum.
" squamosa (L. speciosa) = L. pecten.
" divaricata (L. Conradi).
" crenulata.
? Cardium Carolinense = C. magnum?
? " muricatum.
? Cardita tridentata.
Gouldia lunulata.
Pandora trilineata.
Venus mercenaria.
? Cytherca cribraria = C. punctulata?
Cytherea cancellata (C. cingenda).
Petricola pholadiformis.
Tellina alternata.
" polita.
" lusoria.
Strigilla flexuosa.
Cumingia tellinoides.
Amphidesma (Abra) equalis.
" (Semele) orbiculata.
? Donax variabilis.
Standella fragilis (Mactra oblongata).
Mactra similis = Hemimactra solidissima.
" lateralis.
Solecurtus Caribæus (Siliquaria Carolinensis).
Solen ensis (S. directus).
Pholas costata (P. arcuata).
" (Dactylina) oblongata (P. producta).

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* These proportions strikingly corroborate the author's original assumption of two distinct horizons, based upon an examination of Maryland fossils alone.

† The author desires to express his indebtedness to Mr. George W. Tryon, Jr., through whose kind assistance most of the comparisons with recent forms were made.

Note.—About ten other species have been considered by various authors to be equivalents of recent forms, but since their identification as such has been at best but very doubtful, and in most cases strictly erroneous, they have been omitted. Among these are:—

Lucina anodonta, at one time considered by Mr. Conrad to be identical with a species living along the Florida coast. Although very closely resembling the *L. Floridana*, it may, nevertheless, be readily distinguished from it by the greater thickness of its shell, and the greater profundity of the lunules.

Cardita arata.—This species differs, as stated by Conrad (Mioc. Foss., p. 12), from the recent *C. Floridana* of the Florida coast in being proportionately longer and broader behind, and in having the ribs crossed by "crowded subsquamose transverse wrinkles," instead of "thick transverse tubercles."

Cardita granulata.—According to Conrad (Mioc. Foss., p. 13) this shell "so nearly resembles *C. borealis*, a recent species of the eastern coast, that I think it will prove to be the same, when more specimens of the latter shall be obtained for comparison." This identification, which was subsequently rejected by Conrad himself, has for its support the very similar general appearance presented by the two shells in question, but closer examination shows the *C. granulata* to be almost invariably a considerably more elevated (less rotund) form than the *C. borealis*.

Artemis intermedia.—Not readily confoundable with either the *A. concentrica* (Born) or *A. Floridana* (Conr.).

Cytheria Sayana.—More produced (less rounded) than the recent *C. convexa*.

Rangia clathrodonta.—More elongated than the recent *R. cyrenoides*.

Admitting both the positive and somewhat doubtful forms from the above list to be recent, then we have as a proportion to extinct forms 40 to 103, or 39 per cent.; or if the six doubtful ones are omitted, 34 to 103, or 33 per cent.

The following recent species may be considered to occur in the North Carolina deposits:—

Anomia ephippium.
Ostrea Virginiana.
Pecten Clintonius = P. Magellanicus.
Arca lienosa = A. Floridana.
Leda acuta.
Yoldia limatula (Leda lævis).
Nucula proxima = N. obliqua.
Chama arcinella.
?Cardita tridentata.
Gouldia lunulata.
?Cardium Carolinense = C. magnum?
" muricatum.
Lucina Pennsylvanica.
" contracta = L. filosa.
" crenulata.
" radians = L. Antillarum.
Lucina divaricata (L. Conradi).
" squamosa (L. speciosa) = pecten.
Venus mercenaria.
?Cytherea cribraria = C. punctulata?
Tellina lusoria.
" alternata.
" polita.
Strigilla flexuosa.
Mactra oblongata = Standella fragilis.
" lateralis.
" similis = Hemimactra solidissima.
Solen ensis.
Solecurtus Caribæus (Siliquaria Carolinensis).
Pholas costata (P. arcuata).
" (Dactylina) oblongata.
?Pandora trilineata.

Of the above 32, which constitute 30 per cent. of the lamellibranchiate fauna of the State, all, with only one exception—*Pecten Clintonius* (*Magellanicus*)—also occur in the South Carolina deposits. Although the percentage of recent forms in the

North Carolina formations is thus shown to be considerably lower than in South Carolina, yet in view of the very strong correspondence—one might, indeed, say identity—existing between the two faunas generally, this variation can scarcely be taken to affect the conclusion already arrived at as to the contemporaneity of the two formations.

In Virginia (of 109 forms) the number of recent species, including several doubtful ones, in reduced to 16, as exhibited in the accompanying enumeration:—

Ostrea Virginiana.
Pecten Clintonius = P. Magellanicus.
? Arca protractra = A. lienosa (*et* A. Floridana)?
Yoldia limatula.
Nucula obliqua = N. proxima.
Gouldia lunulata.
Lucina squamosa (L. speciosa) = L. pecten.
" crenulata.
Lucina divaricata.
" contracta = L. filosa.
? Venus mercenaria.
Tellina lusoria.
Cumingia tellinoides.
Pandora crassidens = P. trilineata.
Saxicava bilineata = S. rugosa.
? Pholas acuminata = P. costata?

The percentage (15) is here, therefore, brought down considerably lower than in either of the preceding States, a circumstance not only strikingly confirming the assumption of non-contemporaneity (as has already been drawn from comparisons made between the different faunas themselves) in the deposits in question, but equally proving that the Virginia deposits are anterior (older) in date to those of both South and North Carolina.

The number of recent species occurring in the Maryland deposits taken as a whole (*i. e.*, as embracing both the "newer" and "older" groups, and comprising, consequently, 98 specific forms of acephalous mollusks) is somewhat less than in Virginia, namely (including two or three doubtful forms), 13:

Leda acuta.
Yoldia limatula (Leda lævis).
Nucula proxima = N. obliqua.
Lucina crenulata.
" contracta = L. filosa.
" divaricata.
Ostrea Virginiana.
Pecten Clintonius = P. Magellanicus.
Panopæa Americana.[*]
? Venus mercenaria.
Solen ensis.
Saxicava rugosa (S. bilineata).
? Pholas ovalis = P. costata?

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[*] I have here provisionally included the *Panopæa Americana* among the recent forms, although I am somewhat doubtful as to its right to a place there. The shell certainly very greatly resembles that of the recent *P. Aldrovandi* from the Mediterranean, from which, in fact, it appears to differ only in the form of the posterior truncature, which in the recent species carries up the hinge line to a higher level than in the fossil. While the form of the American shell is very constant, that of the European is stated to be very varying, and therefore the distinction pointed out may on a closer examination between specimens be found to have no specific value. By Searles Wood ("Monograph of the Crag Mollusca," ii, p. 283, Palæontogr. Soc. Reports) the *P. Americana* (and *P. reflexa*) is considered identical with the *P. Faujasii* (more properly *P. Menardi*), a common European fossil, and one which had frequently been confounded with the recent *P. Aldrovandi;* but the American species appears to be at least as much related, if not more so, to the living form. The *P. reflexa* is stated by Mayer (*Catalogue Systématique des Foss. des Terr. Tert.*, ii, pp. 25 and 42) to be living on the coast of New Zealand, and to be identical with the *P. Salandri* of Gray; the angulation on the posterior slope of the latter, however, readily distinguishes the two.

Of this number 12 are found in the deposits of the "newer" group, and consequently constitute about 18 per cent. of its lamellibranch fauna; on the other hand, at most only 2 occur in the deposits of the "older" group. We have here, therefore, not only a further corroboration of the existence in the State of two distinct horizons, but what might almost be considered positive proof that the upper Maryland formation ("newer" group), occupies a horizon very nearly identical with that of the (or the great bulk of the) Virginia formation, and one considerably lower than that indicated by the South and North Carolina deposits, despite the circumstance that the general relations existing between the respective faunas in the two cases are not very different.

The following statement summarizes the results obtained from the examination of the lamellibranch fauna:—

Of about 103 South Carolina species—
74–78 are found in North Carolina = 74 per cent.
43 are found in Virginia = 42 per cent.
34 are found in Maryland = 33 per cent.
34–40 are recent = 33–39 per cent.

Of about 106 North Carolina species—
74–78 are found in South Carolina = 74 per cent.
48 are found in Virginia = 46 per cent.
36 are found in Maryland = 34 per cent.
32 are recent = 30 per cent.

Of about 109 Virginia species—
43 are found in South Carolina = 40 per cent.
48 are found in North Carolina = 44 per cent.
41 are found in Maryland = 38 per cent.
16 are recent = 15 per cent.

Of about 98 Maryland species—
34 are found in South Carolina = 35 per cent.
36 are found in North Carolina = 37 per cent.
41 are found in Virginia = 42 per cent.
13 are recent = 13 per cent.

Of about 66 Maryland "Newer" group species—
33 are found in South Carolina = 50 per cent.
32 are found in North Carolina = 49 per cent.
37 are found in Virginia = 56 per cent.
12 are recent = 18 per cent.

Of about 32 Maryland "Older" group species—

4 are found in South Carolina = 13 per cent.
7 are found in North Carolina = 22 per cent.
8 are found in Virginia = 25 per cent.
2 are recent = 7 per cent.

The examination of the gasteropod faunas of the several States, as will be seen from the summary further on, very strongly confirms the results that have been obtained from the investigation of the acephalous mollusks.

The following enumeration exhibits the species that have been described from the deposits of South and North Carolina.

South Carolina.

Cancellaria reticulata,	N. C.
" depressa.	
" venusta.	
Conus adversarius,	N. C.
" diluvianus,	N. C.
Crucibulum multilineatum,	N. C.
" costatum,	N. C.
" ramosum,	N. C.
" dumosum,	N. C.
Cypræa Carolinensis,	N. C.
Crepidula fornicata,	N. C.
" spinosa = C. aculeata,	N. C.
" plana = C. unguiformis,	N. C.
" costata.	
Columbella avara.	
Dentalium attenuatum = D. dentale,	N. C.
" Pliocenum.	
" thallus,	N. C.
Dolium galea.	
Ecphora quadricostata,	N. C.
Fasciolaria distans = F. tulipa,	N. C.
" (?) gigantea.	
" Tuomeyi.	
Fulgur carica,	N. C.
" perversus,	N. C.
" canaliculatus,	N. C.
" Conradi (incile).	
" Carolinensis (F. excavatus),	N. C.
" pyrum (F. spiratus),	N. C.
Ficus reticulatus,	N. C.
Fusus exilis,	N. C.
Fissurella redimicula,	N. C.
Galeodia Hodgei,	N. C.
Hipponyx Bullii.	
Infundibulum centralis,	N. C.
Littorina irrorata.	
Marginella limatula,	N. C.
Marginella oliviformis,	N. C.
Mitra Carolinensis,	N. C.
Monodonta Kiawahensis.	
Murex umbrifer,	N. C.
Natica heros,	N. C.
" duplicata,	N. C.
" canrena,	N. C.
" Caroliniana.	
Nassa vibex,	N. C.
" trivittata,	N. C.
" obsoleta,	N. C.
" (?) lunata.	
Obeliscus arenosus,	N. C.
Oliva literata,	N. C.
Pleurotoma lunata,	N. C.
Ptychosalpinx porcinum,	N. C.
" multirugatum,	N. C.
Purpura tridentata.	
Petaloconchus sculpturatus,	N. C.
Ranella caudata,	N. C.
Scalaria multistriata,	N. C.
" clathra = S. angulata,	N. C.
Solarium perspectivum.	
Terebra Carolinensis,	N. C.
" unilineata,	N. C.
Trivia pediculus,	N. C.
Turritella striata.	
" exaltata.	
" Burdenii,	N. C.
" Etiwaensis,	N. C.
Trochus philantropus,	N. C.
" armillatus.	
" gemma.	
Urosalpinx cinerea.	
Voluta mutabilis,	N. C.
" Trenholmii,	N. C.
Vermetus anguina.	

North Carolina.

Cancellaria Carolinensis = C. reticulata,	S. C.
Cæcum annulatum.	
Cerithium moniliferum.	
" (Cerithiopsis) annulatum.	
" bicostatum.	
Chemnitzia subulata.	
Conus adversarius,	S. C.
" diluvianus,	S. C.
Crucibulum multilineatum,	S. C.
" costatum,	S. C.
" ramosum,	S. C.
" dumosum,	S. C.
Cypræa Carolinensis,	S. C.
Crepidula fornicata,	S. C.
" spinosa = C. aculeata,	S. C.
" plana (C. unguiformis),	S. C.
Carinorbis (Delphinula) quadricostata.	
Dentalium attenuatum = D. dentale,	S. C.
" thallus,	S. C.
Dolium octocostatus.	
Ecphora quadricostata,	S. C.
Eulima (?) lævigata.	
Erato lævis?	
Fasciolaria distans = F. tulipa,	S. C.
" elegans.	
" Sparrowi.	
" alternata.	
" nodulosa.	
" acuta.	
Fulgur carica,	S. C.
" contrarius = F. perversus,	S. C.
" canaliculatus (? F. rugosus),	S. C.
" Carolinensis = F. excavatus,	S. C.
" pyrum = F. spiratus,	S. C.
Ficus reticulatus,	S. C.
Fusus exilis,	S. C.
" equalis.	
" lamellosus.	
" moniliformis.	
Fissurella redimicula,	S. C.
Galeodia Hodgei,	S. C.
Infundibulum centralis,	S. C.
Littorina lineata.	
Marginella limatula,	S. C.
" oliviformis,	S. C.
" constricta.	
" ovata.	
" inflexa.	
" elevata.	
Mitra Carolinensis,	S. C.

Murex umbrifer,	S. C.
" globosa.	
Natica heros,	S. C.
" duplicata,	S. C.
" canrena,	S. C.
" fragilis,	
" percallosa.	
" Emmonsii.	
Nassa vibex,	S. C.
" trivittata,	S. C.
" obsoleta,	S. C.
" (Tritia) multilineatum.	
" " moniliformis.	
" " bidentata.	
Obeliscus arenosus,	S. C.
Oliva literata,	S. C.
" ancillariæformis.	
" canaliculata.	
Pleurotoma lunata,	S. C.
" limatula.	
" communis.	
" elegans.	
" tuberculata.	
" flexuosa.	
Ptychosalpinx porcinum,	S. C.
" multirugatum,	S. C.
Petaloconchus sculpturatus,	S. C.
Pyramidella reticulata.	
Ranella caudata,	S. C.
Scalaria multistriata,	S. C.
" clathra,	S. C.
" curta.	
Terebra Carolinensis,	S. C.
" unilineata,	S. C.
" neglecta.	
Tornatina cylindra.	
Trivia pediculus,	S. C.
Turritella Burdenii,	S. C.
" Etiwaensis,	S. C.
" constricta.	
Turbonilla reticulata.	
Trochus philanthropus,	S. C.
Voluta mutabilis,	S. C.
" Trenholmii,	S. C.
" obtusa.	
Helix tridentata.	
" labyrinthica.	
Planorbis bicarinatus.	
Paludina subglobosa.	

A comparison of the two preceding tables shows, that of the 74 South Carolina forms no less than 52 (or 70 per cent.) are common to the deposits of North Carolina, a proportion very nearly identical with that which obtains in the case of the acephalous mollusks (74 per cent.). This very close agreement leaves but little, if any, room for doubt as to the contemporaneity of the formations of the two States. In North Carolina the number of specific forms described is considerably in excess of that from the former State, and consequently, as must almost necessarily follow, the percentage of common forms is here very materially reduced. Thus of 100 species—4 of which are non-marine—only 52, as above stated, also occur in South Carolina, or just 52 per cent. It is but fair to presume, however, that were the number of species described from South Carolina equal to that from North Carolina, the proportion of forms common to the two States, while it would not probably differ very materially from what we now find it in the former State, would be considerably raised for the latter. On the other hand, just the reverse result presents itself when a comparison is made with the Virginia fauna, which comprises a far greater number of species than is to be found in any other State:

Virginia.

Amycla reticulata.	
Actæon (?) milium.	
Adeorbis (Delphinula) costulata.	
" " **concava (A. lipara).**	
" " **obliqué-striata.**	
Anguinella Virginiana.	
Bela Dædalia.	
Buccinum Tuomeyi.	
" **frumentum.**	
Crepidula costata,	S. C.
" **fornicata,**	S. C.; N. C.
" **spinosa,**	S. C.; N. C.
" **ponderosa.**	
" **cornucopiæ.**	
" **cymbiformis.**	
Crucibulum costatum, (Calyptrea pileolus).	S. G.; N. C.
" **ramosum,**	S. C.; N. C.
" **grande.**	
Cemoria oblonga.	
Capulus lugubris.	
Cancellaria perspectiva.	
" **plagiostoma.**	
Çerithium clavulus.	
" **curtum.**	
Cerithiopsis annulatum,	N. C.
Chiton transenna.	
Cylichna cylindrica.	
" **Virginiana.**	
Chemnitzia (Pasithea) subula,	N. C.
" " **exarata.**	
" " **eburnea.**	
Dentalium thallus,	S. C.; N. C.
" **attenuatum = D. dentale,**	S. C.; N. C.
Delphinula trochiformis.	
" **(Carinorbis) arenosa.**	
" **lyra.**	
Ecphora quadricostata,	S. C.; N. C.
Eulima (Pasithea) lævigata,	N. C.
" **eborea.**	
" **migrans.**	
Eulimella (Pasithea) ovulum (E. diaphana).	
Fasciolaria parvula.	
" **rhomboidea=F. distans.**	S. C.; N. C.
Fissurella redimicula,	S. C.; N. C.
" **catilliformis.**	
Fulgur carica,	S. C.; N, C.
" **canaliculatus,**	S. C.; N. C.
" **incile (Conradi),**	S. C.
" **tritonis.**	
" **filosus.**	
" **carinatus.**	
" **maximus.**	
Fusus (Neptunea) exilis,	S. C.; N. C.
" **strumosus.**	
" **(Neptunea) trossula.**	
Marginella limatula,	S. C.; N. C.
" **perpusilla.**	

Marginella conulus.
" exilis.
" eburneola.
Mangelia Virginiana.
Menestho limnea.
Melampus (?) longidens.
Nassa trivittata, . . . S. C.; N. C.
" impressa.
" (Tritia) altilis.
" " bilix.
" " laqueata.
Natica duplicata, . . . S. C.; N. C.
" heros, ... S. C.; N. C.
" aperta (N. fragilis ?), . . N. C.
" sphærula (N. percallosa ?), . N. C.
" perspectiva.
Niso lineata.
Oliva canaliculata, ... N. C.
" ancillariæformis, . . . N. C.
" Carolinensis = O. literata, S. C.; N. C.
" eborea.
Obeliscus arenosus (Pyramidella suturalis). S. C.; N. C.
Odostomia (Actæon) granulatus.
" (?) globosus.
" " turbinatus.
" " angulatus.
" " glans.
" " sculptus.
" " nitens.
Patella acinaces.
Petaloconchus sculpturatus, . S. C.; N. C.
Pleurotoma lunata, . . . S. C.; N. C.
" pyrenoides.
" (Drillia) multisecta.
" " arata.
" " bella.
" " distans.
" " dissimilis.
" " eburnea.
" " impressa.
" (Surcula) engonata.
Pleurotoma (Surcula) nodulifera.
" " tricenaria.
" " Virginiana.
Pyramidella elaborata.
Ptychosalpinx porcinum, . . S. C.; N. C.
Rotella nana.
" subconica.
" carinata.
" lenticularis.
" umbilicata.
Scalaria clathra = S. angulata. S. C.; N. C.
" acicula.
" micropleura.
" microstoma (S. cornigera ?).
" pachypleura.
" procera.
Solarium nupera.
Trochus philanthropus, . . S. C.; N. C.
" armillus.
" conus.
" lens.
" torquatus.
" Ruffinii.
" bellus.
" labrosus.
" Mitchelli.
Turbo rusticus.
" (Monilea) caperata.
Trophon tetricus.
Turritella variabilis.
" indenta.
" plebeia.
" alticosta.
" flexionalis.
" terstriata.
" bipertita.
Trochita (Infundibulum) concentrica.
Triforis (Cerithium) monilifera.
Urosalpinx cinerea.
Vermetus convolutus.
Voluta mutabilis, . . . S. C.; N. C.
Vivipara (Turbo) glaber.

NOTE.—Several species described by H. C. Lea (Amer. Philos. Trans., new ser., vol. ix), considered to have been founded on insufficiently determined characters, or on the immature forms of previously described species, have been intentionally omitted.

We find that of the 141 species here enumerated only about 26 are found in the deposits of South Carolina, which would give to that State a comparatively low percentage of common forms (35), and one considerably less than that (42) which was found to exist when the acephalous mollusks were taken as the basis of comparison. Nor is the number of Virginia forms (31) occurring in North Carolina much more numerous, and here, likewise the percentage (31) is markedly lower than was found to be the case (46) in the first method of comparison. Taking these various facts together they are abundantly conclusive as to the correctness of the inference drawn from the testimony of the lamellibranchs, that the Virginia deposits represent a horizon different from that indicated by the South and North Carolina formations.

From the Maryland deposits taken as a whole, *i. e.*, as comprising both the "newer" and "older" groups, there have thus far been described about 105 species of gasteropodous mollusks; of these, as will be seen from the following table, about 21 (20 per cent.) also occur in South Carolina, and 26 (or 25 per cent.) in Virginia. While the proportion of forms common to the two States is thus shown to be very limited in either case, and decidedly less than was found to exist among the lamellibranchs, there is yet (as was also indicated in the lamellibranch comparisons) a slight advantage in favor of Virginia.

Maryland.—Newer Group.

Actæon ovoides.	
" melanoides.	
Bulla (?) acuminata.	
Cancellaria corbula.	
" lunata.	
" alternata.	
Cassis (Semicassis) cælata.	
Crucibulum grande,	Va.
" tubiferum.	
" costatum,	S. C.; N. C.; Va.
Conus diluvianus,	S. C.; N. C.
" Marylandicus.	
Columbella communis.	
" avara,	S. C.
Dentalium thalloides.	
" attenuatum = D. dentale.	S. C., N. C.; Va.
Ecphora quadricostata,	S. C.; N. C.; Va.
Fusus (Neptunea) parilis.	
" " errans (rusticus).	
" sulcosus.	
" strumosus,	Va.
Fissurella alticosta.	
" nassula.	
" redimicula,	S. C.; N. C.; Va.
Fulgur rugosus?	
" coronatus.	
" canaliculatus,	S. C.; N. C.; Va.
" tuberculatus.	
" carica,	S. C.; N. C.; Va.
" fusiformis.	
Fulgur alveatus?	
Ficus? (Pyrula) sulcosa.	
Marginella denticulata.	
Melanopsis (Bulliopsis) ovata.	
" integra,	Va.?
" Marylandica.	
Natica interna.	
" duplicata,	S. C.; N. C., Va.
" heros,	S. C.; N. C.; Va.
" fragilis,	N. C.; Va.
Nassa trivittata,	S. C.; N. C.; Va.
" obsoleta,	S. C.; N. C.
" lunata,	S. C.
" quadrata.	
" prærupta.	
" porcinum,	S. C.; Va.
" arata.	
Pleurotoma bicatenaria.	
" limatula,	N. C.
" communis,	N. C.
" parva.	
" rotifera.	
" gracilis.	
" dissimilis,	Va.
Ranella centrosa = R. caudata?	S. C.? N. C.?
Scalaria clathra = S. angulata.	S. C.; N. C.; Va.
" expansa.	
Terebra simplex.	
" curvilineata.	
" loxonema.	
Trochus humilis.	

Trochus reclusus.	
" Bryanii.	
Turbo (Monilea) distans.	
" " eborca.	
Turritella plebeia,	Va.
" variabilis,	Va.
" laqueata.	
" solitaria.	
" alticosta,	Va.
Turritella octonaria.	
Turbinella demissa.	
Turbonilla perlaqueata.	
Trophon tetricus,	Va.
Typhis acuticostata.	
Urosalpinx cinerea,	S. C.; Va.
Voluta mutabilis,	S. C.; N. C.; Va.
" solitaria.	

Maryland—Older Group.

Buccinum? protractum.	
" lienosum.	
Bulla subspissa.	
Cancellaria biplicifera.	
" engonata.	
Crucibulum ramosum,	S. C.; N. C.; Va.
" constrictum.	
Dentalium thalloides.	
Fissurella Marylandica.	
Fusus migrans.	
" (Neptunea) devexus.	
Marginella perexigua.	
Niso lineata,	Va.
Pleurotoma Marylandica.	
" bellacrenata.	
" rugata.	
Scalaria pachypleura,	Va.
Solarium trilineatum.	
Sigaretus fragilis.	
Trochita (Infundibulum) perarmata.	
Turritella indenta,	Va.
" exaltata,	S. C.
" perlaqueata.	
Trochus peralveatus.	
Valvula iota.	
Voluta mutabilis,	S. C.; N. C.; Va.
" solitaria.	

Taking each of the two Maryland divisions already referred to by itself, we find that of the 21 forms occurring also in South Carolina, 19 belong to the deposits of the "newer" group, which comprise in all about 78 species; the percentage of forms common to the two formations—25—is thus considerably above that which was found to obtain when the State formation was considered as a whole. And the same increased percentage is determined when the Virginia forms are considered. Of the 26 indicated in the preceding enumeration, 22 belong to the "newer" group, of whose fauna they consequently constitute 28 per cent. The 27 species belonging to the "older" group have only 3 (or 10 per cent.) common with South Carolina, and 5 (or 18 per cent.) common with Virginia. In comparing the gasteropod faunas of the two Maryland divisions with each other, we find that there are only three species whose range embraces the deposits of both series. From the preceding data it will be seen that very strong confirmation is lent to the conclusions derived from the examination of the lamellibranch fauna as to the non-contemporaneity of the South Carolina (*et conseq.*, North Carolina) deposits with those of Virginia and Maryland, and to the existence of two well-marked faunal horizons in the last-named State. No conclusive evidence is, however, afforded relative to the position which the Virginia and Maryland deposits hold in respect of each other; for the determination of this point, as well as for the determination of the several horizons, testimony must again be sought in the relations which the extinct faunas bear to the fauna of existing seas.

Species still living found in the South Carolina deposits:

Dentalium attenuatum = D. dentale.
Crepidula fornicata.
“ spinosa = C. aculeata.
“ plana = C. unguiformis.
Natica heros (N. catenoides).
“ duplicata.
“ canrena (N. plicatella).
Littorina irrorata (L. Carolinensis).
? Solarium perspectivum.
Scalaria multistriata.
“ clathrus = S. angulata.
Obeliscus arenosus.
Trivia pediculus.
Nassa vibex.
“ trivittata.
“ obsoleta.
Dolium galea.
Columbella avara.
Oliva literata (O. Carolinensis).
Ranella (Bursa) caudata.
Cancellaria reticulata (C. Carolinensis).
Fulgur carica.
“ perversum (F. adversarium).
“ canaliculatum (F. canaliferum).
“ pyrum.
Urosalpinx cinerea (Peristernia filicata).
Fasciolaria distans (F. rhomboidea) = F. tulipa.

NOTE.—Three or four additional species, for several reasons here omitted, may on further examination be found to be identical with recent forms.

Thus, out of a total number of 74 species about 27 are still found living at the present day; the percentage of recent to extinct species—37—is therefore not very different from that which was found to obtain among the acephalous mollusks.

The following recent species may be considered to occur in North Carolina:

Dentalium attenuatum = D. dentale.
Crepidula fornicata.
“ spinosa = C. aculeata.
“ plana = C. unguiformis.
Natica heros (N. catenoides).
“ duplicata.
“ canrena (N. plicatella).
Scalaria multistriata.
“ clathrus = S. angulata.
Obeliscus arenosus.
Trivia pediculus.
Nassa vibex.
“ trivittata.
“ obsoleta.
Oliva literata (O. Carolinensis).
Ranella (Bursa) caudata.
Cancellaria reticulata (C. Carolinensis).
Fulgur carica.
“ perversum (F. contrarium).
“ canaliculatum.
“ pyrum (F. spirata).
Fasciolaria distans = F. tulipa.

All of the above 22 species, which constitute 22 per cent. of the gasteropod fauna of the State, are found also in South Carolina. We have here, just as in the case of the lamellibranch fauna, a decided decrease when compared with the last-mentioned State in the proportion of living forms, but yet, as before, the very well marked correspondence or identity existing generally between the two faunas would preclude the supposition of the representation by them of two distinct horizons.

In Virginia and Maryland the number of recent species is considerably less than in either South or North Carolina, and the proportion these bear to extinct forms is also very materially reduced. Thus of about 141 Virginia species only 12 (or 8½ per cent.) can be considered as being identical with living forms, namely:

Dentalium attenuatum = D. dentale.
Crepidula fornicata.
" spinosa = C. aculeata.
Natica duplicata.
" heros (N. catenoides).
Fulgur carica.
Fulgur canaliculata.
Oliva Carolinensis = O. literata.
Scalaria clathra = S. angulata.
Nassa trivittata.
Obeliscus arenosus (Pyramidella suturalis).
Urosalpinx cinerea.

The number of recent species occurring in the Maryland deposits is about equal to that from Virginia; but here, owing to the limited extent of the fauna, the proportion to extinct forms is considerably increased. It is a significant fact that all the recent species belong to the "newer" group, and none to the "older." They are as follows:

Columbella avara.
Fulgur carica.
" canaliculata.
Urosalpinx cinerea.
Dentalium attenuatum = D. dentale.
Nassa trivittata.
Nassa obsoleta.
Natica duplicata.
" heros (N. catenoides).
Scalaria clathra = S. angulata.
? Ranella centrosa = R. (Bursa) caudata?

The percentage of recent forms is here, therefore, brought up to fourteen, or very nearly that (15) which obtains among the Virginia lamellibranchs, and four per cent. below that which was found to characterize the lamellibranch fauna for the same group of deposits.

Summing up the results obtained from the examination of the gasteropod fauna, we find that—

Of about 74 South Carolina species—
    52 are found in North Carolina = 70 per cent.
    26 are found in Virginia = 35 per cent.
    21 are found in Maryland = 29 per cent.
    27 are recent = 37 per cent.

Of about 100 North Carolina species—
    52 are found in South Carolina = 52 per cent.
    31 are found in Virginia = 31 per cent.
    18 are found in Maryland = 18 per cent.
    22 are recent = 22 per cent.

Of about 141 Virginia species—
  26 are found in South Carolina = 19 per cent.
  31 are found in North Carolina = 22 per cent.
  26 are found in Maryland = 19 per cent.
  12 are recent = 8½ per cent.

Of about 105 Maryland species—
  21 are found in South Carolina = 20 per cent.
  18 are found in North Carolina = 17 per cent.
  26 are found in Virginia = 25 per cent.
  11 are recent = 11 per cent.

Of about 78 Maryland "Newer" group species—
  19 are found in South Carolina = 25 per cent.
  17 are found in North Carolina = 22 per cent
  22 are found in Virginia = 28 per cent.
  11 are recent = 14 per cent.

Of about 27 Maryland "Older" group species—
  3 are found in South Carolina = 10 per cent.
  2 are found in North Carolina = 8 per cent.
  5 are found in Virginia = 19 per cent
  0 recent.

It will be readily perceived from the preceding summarized statement that the general results obtained from the examination of the gasteropod faunas abundantly confirm the conclusions drawn from the study of the acephalous mollusks. Combining the results obtained from the two methods of comparison, we find that:

Of about 177 South Carolina mollusca—
  128 are found in North Carolina = 72 per cent.
  69 are found in Virginia = 39 per cent.
  55 are found in Maryland = 31 per cent.
  61–67 are recent = 35–38 per cent.

Of about 206 North Carolina mollusca—
  128 are found in South Carolina = 62 per cent.
  79 are found in Virginia = 38 per cent.
  54 are found in Maryland = 26 per cent.
  54 are recent = 26 per cent.

Of about 250 Virginia mollusca—
  69 are found in South Carolina = 28 per cent.
  79 are found in North Carolina = 32 per cent.
  67 are found in Maryland = 27 per cent.
  28 are recent = 11 per cent.

Of about 203 Maryland mollusca—

55 are found in South Carolina = 27 per cent.
54 are found in North Carolina = 27 per cent
67 are found in Virginia = 33 per cent.
24 are recent = 12 per cent.

Of about 144 Maryland "Newer" group mollusca—

52 are found in South Carolina = 36 per cent.
49 are found in North Carolina = 34 per cent.
59 are found in Virginia = 41 per cent.
23 are recent = 16 per cent.

Of about 59 Maryland "Older" group mollusca—

7 are found in South Carolina = 12 per cent.
9 are found in North Carolina = 15 per cent.
13 are found in Virginia = 22 per cent.
2 are recent = 4 per cent.

Summary.

The following points in stratigraphy, it is believed, may be considered as being conclusively demonstrated through the foregoing comparisons:—

1. That the South and North Carolina deposits represent approximately the same geological horizon;

2. That the Virginia deposits indicate a horizon lower (older) in the geological scale than that of either of the formations just mentioned;

3. That the Maryland deposits indicate two well-marked faunal horizons, of which the upper one is the correspondent of the Virginian.

REMARK.—It will be seen from the last table that the correspondence existing generally between the Maryland deposits taken as a whole (*i. e.*, including both "newer" and "older" groups) and those of Virginia is greater than that which obtains between the last and the deposits of the "newer" group (upper Maryland horizon) considered alone, and, hence, it might readily be concluded that the Virginia and Maryland formations are absolutely equivalents of each other. But, as it has already been shown, the Maryland deposits almost unquestionably represent two well-defined faunal horizons, and, therefore, unless such is likewise found to be the case in Virginia—which *appears to be highly probable*, although evidence proving the same is still insufficient—no general correlation can be insisted upon.

Having ascertained the relations which the deposits of the several States hold towards each other, it remains lastly to determine what are the horizons, as generally recognized by geologists, that they represent. The low percentage of living forms which characterizes the molluscan faunas of the Maryland and Virginia deposits leaves no doubt as to the Miocene age of these last; the "older" group of Maryland, therefore, represents the base of the Miocene series. As for the North and South Carolina deposits, their position is somewhat more difficult to pronounce upon. The percentage of recent forms occurring in South Carolina is such as to permit, according to the original Lyellian classification of the Tertiary strata, of the deposits of that State being referred to the Pliocene period. The North Carolina deposits, on the other hand, would according to the same system of classification be relegated to the Miocene period, and yet, as has already been seen, the identity existing between the faunas of the two States is altogether too great to admit of any reasonable doubt as to their contemporaneity. Nor is the difficulty of determination lessened when an appeal is made to European deposits of nearly similar age, which have served to elucidate the principles of the Lyellian classification. Thus in what might be considered to be the two typical areas for the occurrence of marine Pliocene deposits in Europe—Italy and England—the percentages of recent forms characterizing the contained faunas vary within very broad limits. Foresti has shown (*vide* Fuchs, *Die Gliederung der Tertiärbildungen am Nordabhange der Apenninen von Ancona bis Bologna*, Sitzb. d. k. Akademie der Wissenschaften, lxxi, p. 177, Vienna, 1875) that the so-called Pliocene of the Bolognese Apennines may be divided into four faunal horizons, the deposits belonging to which are characterized by the following percentages of recent forms;—

		Total number of species.	Living.	Percentage of living forms.
	IV.	141	112	79·4
	III.	332	144	43·3
	II.	183	71	38·8
(Oldest)	I.	78	24	30·7

Nos. I and II, therefore, correspond very closely in the proportion of living forms with the North and South Carolina deposits. But just this division of the sub-Apennine formation, or its equivalent, is by many Italian geologists referred to the upper Miocene, and, indeed, it would appear more natural, if the percentage of living forms is to remain the principal basis for the classification of the Tertiary formations, to group the doubtful deposits here, and thereby increase the latitude of the Miocene, than where they have very generally been placed, unless, as would seem from the observations of Pareto (*Les terrains tertiaires de l'Apennin septentrional*, Bulletin de la Société Géologique de France, 2d ser., vol. xxii, 1864–5, p. 237, *et seq.*), and Fuchs (*loc. cit.*), stratigraphical evidence is decidedly contrary to such an approximation.* In the English Pliocene faunas the percentages of recent forms are very much higher than in the Italian just referred to.* The following table exhibits the numerical relations of the living and extinct species, which together constitute the Crag molluscan fauna (Lyell, "Student's Elements of Geology," 1878, p. 183, *emend.*):—

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* A direct continuity between the upper Miocene (Tortonian) and the Bolognese sub-Apennine (Pliocene of most authors) formations is maintained by Capellini (Sui Terreni Terziari di una parte del versante settentrionale dell'Apennino, Mem. Accad. Scienze, Istit. Bologna, ser, iii, vol. vi, p. 618, 1876). Under the strata designated as the Mio-Pliocene ("Messinian" of Mayer), corresponding in a general way with the "Sarmatian" and "Congerian" of the Austrian geologists, and consequently comprising (as generally recognized by geologists) deposits of both Miocene and Pliocene age, are included I and II of Foresti's faunal horizons—the lower sub-Apennine marls and sands of Capellini (upper Messinian of Mayer). The upper marls and sands (III and IV) are referred to the "Astian" (or Pliocene proper of Capellini). This classification appears to be more in consonance with the facts presented by paleontology than the one usually followed.

	Total number of species.	Living.	Percentage of recent forms.
Newer Pliocene.			
Chillesford beds, . . .	88	74	84·1
Norwich (Fluvio-marine), . .	112	94	84
Older Pliocene.			
Red Crag (exclusive of derivatives),	248	179	72·2
Coralline Crag, . . .	396	252	63·6

It will thus be seen that the number of recent forms occurring in the *oldest* division of the British Pliocene deposits is, proportionately to the extinct species, very much greater—in fact, not far from twice as great—than that which has been found to exist in the case of the South Carolina deposits. While it may be safe to affirm from this disparity existing between the American and English faunas that the formations represented by them are in no way equivalents of each other (an equivalency, as has already been stated, that had been assumed by Lyell), it may yet be rash to conclude from this reason alone, that, broadly measured, they do not belong to the same period (Pliocene) of geological time, the more especially, since (as will be seen from a comparison of the British and Italian faunal tables) a nearly equal disparity obtains between the faunas of the Crag and some of the sub-Apennine deposits considered to belong to the same period. Nor would it be safe to affirm conclusively, although the evidence in this direction may be considered to be sufficiently strong, that the American deposits in question are correlative of that portion of the sub-Apennine formation, which, by some geologists has been referred to the upper Miocene, or classed as Mio-Pliocene. While it may thus be difficult to determine *absolutely* whether the South Carolina deposits (and, consequently, also the North Carolinian) ought to be classed as Pliocene or Miocene, yet, in view of the fact that thus far no Tertiary beds have been discovered in that State, nor probably anywhere else along the Atlantic coast, whose fauna more closely approximates that of the present day, and the broad hiatus that is thus created between them and the succeeding post-Pliocene, in which, as determined by Holmes ("Post-Pleiocene Fossils of South Carolina," 1860, Introduc., pp. 3 and 4), the recent forms make up fully 99 per cent.

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* Foresti has called attention (*Catalogo dei Molluschi Pliocenici delle Colline Bolognesi*, Mem. Accad. Scienze, Istit. Bologna, ser. ii, vol. vii, p. 548, 1867) to the much greater relationship which the fauna of the Bolognese sub-Apennine formations bears to the fauna of the Vienna basin than to that of the British crag, and from this circumstance draws the inference, that the Italian deposits represent a horizon very close to the Miocene ("*rappresentano un plano geologico vicinissimo al miocene,*" . . .).

of the molluscan fauna,[*] it would appear more natural to group them in the same series with the deposits of Virginia and Maryland, to which, as has been demonstrated by the tables of comparisons, they bear a strong relation. For these reasons the author has preferred to consider them as being of Miocene age, and as representing the uppermost member of the series.[†] The Miocene deposits of the Atlantic slope would, according to this determination, be divisible into three groups:

Upper Atlantic Miocene, represented by the South and North Carolina deposits.

Middle Atlantic Miocene, represented by the whole, or the greater part, of the Virginia deposits, and those of the Maryland "newer" group.

Lower Atlantic Miocene, represented by the deposits of the Maryland "older" group, and, possibly, the lower portion of the Virginia formation.

To these three groups, commencing with the oldest, it is proposed to apply the designations of "Marylandian," "Virginian," and "Carolinian," respectively.

The sequence of the Tertiary formations along the Atlantic and Gulf slopes of the United States would, therefore, be approximately as follows:

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[*] I have had no opportunity as yet of verifying this statement.

[†] But very little evidence as to stratigraphical position is afforded by direct comparisons made between the European and American faunas, since the number of equivalents, or even representative forms is comparatively limited, and these are about equally divided between the European Miocene and Pliocene. The following South Carolina lamellibranchs may be considered to occur, or to have their analogues, in the Crag (Pliocene) deposits:

Anomia ephippium.
Ostrea Virginiana, represented by O. edulis.
Lucina filosa = L. borealis.
" crenulata.
" dentata?
Nucula obliqua = Nucula nucleus?
Astarte bella, represented by Astarte gracilis.
" undulata, represented by A. Omalii.
Artemis intermedia, represented by A. lentiformis
Mactra lateralis, represented by Mactra ovalis.
Solen ensis.
Pandora trilineata = P. inequivalvis?

The following may be said to occur, or to have their analogues, in the deposits of the Vienna basin:

Anomia ephippium, represented by A. costata.
Arca plicatura, represented by A. diluvii.
Nucula obliqua = N. nucleus?
Lucina squamosa = L. pecten (reticulata).
" filosa = L. borealis.
" anodonta = L. Miocenica?
Lucina divaricata, represented by L. ornata?
Chama corticosa, represented by C. gryphina.
Cardium magnum, represented by C. Kübeckii.
Artemis intermedia, represented by A. lentiformis.
Pandora trilineata = P. inequivalvis?

Post-Pliocene.			
Pliocene.	?	?	
Miocene.	Carolinian (Upper Atlantic Miocene).	Deposits of South and North Carolina (" Sumter " epoch of Dana).	
	Virginian (Middle Atlantic Miocene).	Deposits of Virginia, and of the "Newer" group of Maryland (" Yorktown " epoch, in part, of Dana).	Probably of the age of the " Second Mediterranean " of the Austrian geologists, and of the faluns of Touraine.
	Marylandian (Lower Atlantic Miocene).	Deposits of the " Older " group of Maryland, and possibly the lower Miocene beds of Virginia (" Yorktown" epoch, in part, of Dana).	Probably (or at least, partially) the equivalent of the "First Mediterranean " of the Austrian geologists, and of the faluns of Léognan and Saucats.
Oligocene.	Orbitoitic.	Strata characterized by species of *Orbitoides*, etc. Vicksburg beds, Florida beds, etc.	
Eocene.	Jacksonian.	Jackson beds of Mississippi—" White Limestone " of Alabama.	
	Claibornian.	Fossiliferous arenaceous deposit of Claiborne, Ala., etc.	Age of the " Calcaire Grossier " of France (Parisian).
	Buhrstone.	Beds below the true Claibornian on the Alabama River. " Chalk Hills " of the southern part of the State, etc. " Siliceous Claiborne " (Hilgard) of Mississippi.	Londonian ?
	Eo-lignitic.	Lignite, sands and clays situated at the base of the Tertiary series in Alabama, etc. Eocene beds of Maryland ?	Thanetian ?

REMARK.—In the above table, in most instances only the *more prominent* localities for the occurrence of the several deposits have been given, and the absence of reference to certain States, therefore, does not indicate that deposits of a given age are there wanting. The "Jacksonian" beds, which are placed at the top of the Eocene series, may, on further examination, prove to be in part Oligocene. By some geologists a portion of the post-Eocene Tertiary deposits of New Jersey, Delaware, and Maryland has been referred to the Pliocene period, but there does not appear to be as yet sufficient evidence to support such a conclusion. No precise correlation between the entire series of the Atlantic Tertiary deposits of the United States and those of Europe can thus far be said to have been determined. There can be no doubt as to the parallelism existing between the Clairbornian and the "Calcaire Grossier" (Parisian) of France; but as for the immediately overlying and underlying Eocene deposits, their relations can only be approximately fixed from the positions which they occupy in their own series. The "Buhrstone" appears to represent a portion, or perhaps even a greater part of the "Londonian," and the Marlborough and Piscataway beds of Maryland (Eo-lignitic?), a horizon probably not far removed from that of the Bracheux sands of the Paris basin, or the Thanet sands of England (Thanetian). There can be little or no doubt respecting the position of the "Virginian," whose faunal facies places it at about the horizon of the faluns of Touraine, and the "Second Mediterranean" beds of the Vienna basin; nor can there be much more doubt as to the equivalency, at least in part, of the "Marylandian" and the lower Miocene beds of the Vienna basin ("First Mediterranean").* The relations of the "Carolinian" have already been fully discussed.†

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* The proportions which the recent species of mollusca bear to the extinct forms is larger in the *older* deposits of the Vienna basin than in the newer; the percentages for the two divisions of the "Mediterranean" are twenty-one for the "First," and fifteen for the "Second" (Fuchs, *Geologische Uebersicht der jüngeren Tertiärbildungen des Wiener Beckens.* Führer zu den Excursionen der D. Geolog. Gesellschaft, Vienna, 1877, p. 103). The following species of Virginia and Maryland lamellibranchiata may be considered as occurring, or having their analogues, in the deposits of the Vienna basin and the British crag:

VIENNA BASIN.

Saxicava rugosa (bilineata) = S. arctica.
Panopæa Americana, represented by P. Menardi.
Venus latilirata, represented by V. scalaris?
Isocardia fraterna, represented by I. cor.
Chama corticosa, represented by C. gryphina.
Lucina anodonta = L. Miocenica?
" contracta (filosa) = L. borealis.
Lucina divaricata, represented by L, ornata.
" squamosa (speciosa) = L. pecten (reticulata).
Nucula obliqua = N. nucleus?
Arca plicatura, represented by A. diluvii.
Myoconcha incurva, represented by Mytilus Haidingeri?
Perna maxillata = P. Soldanii.

CRAG.

Ostrea Virginiana, represented by O. edulis.
Lucina filosa (contracta) = L. borealis.
" crenulata (Conrad) = L. crenulata (Wood)?
" dentata.
Nucula obliqua = N. nucleus?
Erycinella ovalis.
Astarte undulata, represented by A. Omalii.
Panopæa Americana, represented by P. Menardi.
" porrecta = P. gentilis?
Pandora arenosa (trilineata, *pars?*) represented by P. pinna.
Saxicava rugosa.
Isocardia fraterna, represented by I. cor.

† It is not improbable that the age of the beds of this period will be most nearly represented by that of the deposits of the lower ("Black") Antwerp Crag (Diestian), considered by most Belgian geologists to form the base of the Pliocene series of that country (Dewalque, *Prodrome d'une Description Géologique de la Belgique*, 1880, p. 254), and by Lyell ("Student's Elements," p. 185), as the "first links of a downward passage from the strata of the Pliocene to those of the Upper Miocene period." The percentage (46) of recent molluscan forms characterizing the fauna of these Belgian deposits, as determined by Lyell in 1852 ("On the Tertiary Strata of Belgium and French Flanders," Journ. Geol. Soc. London, viii, p. 293), is, however, considerably higher than that which has been shown to be the case with the Carolinian fauna.

III.

ON THE STRATIGRAPHICAL EVIDENCE AFFORDED BY THE TERTIARY FOSSILS OF THE PENINSULA OF MARYLAND.

The Tertiary deposits of Maryland have from time to time attracted the attention of investigators more or less eminent in their special lines of research, the results of whose observations, owing to the then imperfect state of American geological and paleontological science, only very gradually tended to unfold the true relations existing between the synchronous formations of the east-Atlantic and west-Atlantic countries.

Maclure, on the map accompanying his "Observations of the Geology of the United States" (1817), classed all the late superficial deposits of Maryland under the general term "Alluvial," which term was likewise applied to almost the entire border deposits of the Atlantic and Gulf slopes. In 1824 (Journ. Acad. Nat. Sci., vol. iv) Say described about forty species of fossil shells collected by Mr. Finch from the same State, but excepting some passing reflections on the nature of the deposit whence they were obtained, and on the great resemblance existing between some of the forms and forms still living on the coast, no special geological inferences were drawn from the collection. From a comparative examination of the contained fossils, Van Rensselaer ("Lectures on Geology," 1825, p. 261) subsequently referred the deposits in question to the Upper Marine formation, which view was concurred in by Morton in a paper read before the Academy of Natural Sciences of Philadelphia in June, 1828. In a previous paper ("Geological observations on the Secondary, Tertiary, and Alluvial Formations," J. A. N. S., January, 1828), published conjointly by Vanuxem and Morton, no attempt was made to correlate the various divisions of the American and European Tertiary formations.

Conrad, who, more than any other American geologist, contributed to advance our knowledge of the geology and paleontology of this latest period, was the first to recognize the existence of at least three distinct post-Secondary formations in Maryland, the oldest of which he identified by a series of a few fossils found near Ft. Washington, on the Potomac, as belonging to the Eocene, and the newest, as exposed on the southeast extremity of the peninsula, to the post-Pliocene (J. A. N. S., vol. vi, and Bulletin of the National Institution, 1841). The intermediate deposits were classed as the Upper Marine, but subsequently under Lyell's designation of Miocene. Conrad's original observations were in general confirmed by his later researches, and the relations of at least a great portion of the Miocene of Maryland, as well as of almost the entire Atlantic slope, were clearly pointed out by Lyell in 1845 (Proc. Geol. Soc., vol. iv, p. 547).

It is mainly in relation to this last formation that we wish to draw special attention, there being but little question concerning the original determination of the Eocene and post-Pliocene deposits. That the great bulk of the deposits known as the Medial Tertiary of Maryland is not synchronous with the South Carolina deposits classed by Tuomey and Holmes as Pliocene, an assumed fact insisted upon by Conrad, and for which there appears to be no evidence, an examination of the following table of mollusca will clearly demonstrate:

Lamellibranchiata of the Medial Tertiary Formations of Maryland.

Anomia ephippium,*
Amphidesma carinata,*
“ subovata,
Arca callipleura,
(= A. dipleura?),
“ idonea,
“ incile,*
“ subrostrata,
“ Marylandica,
“ triquetra,
“ centenaria,*
“ improcera,*
“ stilicidium,
Artemis acetabulum,*
“ concentrica,
(= *A. elegans*?),
Astarte vicina,
“ cuneiformis,
“ obruta,
“ perplana,
“ exaltata,
“ varians,
“ distans,
“ planulata,
“ undulata,*
Cardita arata,*
“ protracta,
“ granulata,*
Cardium laqueatum,
“ acutilaqueatum,
“ craticuloides,
“ leptopleura,
Corbula cuneata,*
“ idonea,
“ elevata,
“ inequalis,*
Crassatella Marylandica,
“ turgidula,
“ melina,
“ undulata,*
Cytherea Sayana,*
“ albaria,
(= C. idonea),
“ Marylandica,
“ staminea,
“ subnasuta,*
Isocardia fraterna,
“ Markoei,
Leda liciata,
“ *acuta*,*
“ concentrica,
Lima papyria,
Lepton (?) mactroides,
Lucina anodonta,*
(= L. Americana).
“ Foremani,
“ subobliqua,
“ subplana,
“ cribraria,*
“ *crenulata*,*
“ *contracta*,*
“ *divaricata*,*
Mactra incrassata,
“ ponderosa,
“ fragosa,
“ subcuneata,
“ delumbis,
Modiola Ducatellii,
Mya producta,
Mytilus incurva,
Nucula proxima,*
Ostrea Virginica,*
“ percrassa,*
Panopæa Americana,
“ reflexa,*
“ porrecta,
(= P. Goldfussi?)
Pecten Madisonius,
“ Humphreysii,
“ Jeffersonius,
“ concentricus,
“ *Clintonius*,
“ septenarius,*
Pectunculus parilis,
“ lentiformis,*
“ subovatus,*
Perna maxillata,
Petricola centenaria,
Plicatula marginata,*
Pholadomya abrupta,*
Pholas ovalis,
(= *P. costata*?)*
Saxicava rugosa,
Solen ensis,*
Tellina æquistriata,
“ biplicata,*
“ lenis,
Venus tetrica,
“ *Mortoni*,
“ alveata,
“ inoceriformis,
“ permagna?
“ tridacnoides,*
“ *mercenaria*,*
“ Rileyi.*
Yoldia lævis,*

The species in *italics* are still living on the American coasts; those followed by an * are described by Tuomey and Holmes as occurring in the “Pliocene” formation of South Carolina.

[NOTE.—The preceding table has been compiled as accurately as possible from the various papers pertaining to the paleontology of the State, but owing to their number, and to the numerous publications in which they have been spread, it has proved impossible to collect them all, and no doubt some few species will be found occurring in the State which have escaped our notice. These will probably be very few in number, and will not materially affect the general conclusion. The following twenty-two species, mainly those described by Say from the collection of Mr. Finch (J. A. N. S., vol. iv), have no stated locality: *Arca centenaria*, *A. improcera*, *A. incile*, *Astarte distans*, *Crassatella undulata*, *Leda acuta*, *L. concentrica*, *Nucula proxima*, *Yoldia lævis*, *Lucina contracta*, *L. divaricata*, *L. subobliqua*, *Panopæa reflexa*, *Pecten Jeffersonius*, *P. Clintonius*, *P. concentricus*, *P. septenarius*, *Pectunculus subovatus*, *Plicatula marginata*, *Tellina æquistriata*, *Venus deformis* (*tridacnoides*), *and V. Rileyi.*]

It will thus be seen, that of about one hundred species of bivalves, only thirty-six (36 per cent.) are common to about an equal number (103) from the South Carolina deposits; and further, that, whereas, of the preceding enumeration of Maryland mollusca only about *thirteen* per cent. are recent forms, no less than *thirty-six* per cent. (according to Tuomey and Holmes, nearly fifty per cent.) of the South Carolina medial Tertiary bivalve mollusca are still living. There remains, therefore, no question regarding the relative ages of the two formations.

An examination of the fossiliferous strata exposed in sections at various points on the western shore of Chesapeake Bay, in Anne Arundel and Calvert Counties, on the Patuxent River, near Benedict, and on the St. Mary's River, St. Mary's County, tends to show, moreover, that the series of deposits intermediate between the Eocene of Fort Washington and the post-Pliocene of the southeast extremity of the peninsula belong to two different periods of formation, an older and a newer; those belonging to the latter period being characterized by a fauna, the proportion of living forms in which is far in excess of that in the former. Sections of the newer deposits are exhibited in Calvert County, near Cove Point, on the Patuxent River, below Benedict, at about water level, on the same river, further north, in the deposits *above* the Perna beds, and more especially on the St. Mary's River, St. Mary's County. The older deposits are best shown in the oyster beds, rising a few feet above tide-water, at Fair Haven, Anne Arundel County (which point was considered by Conrad as the northern termination of the peninsular Miocene formation), in similar beds, also only a few feet above water level, at a point about twenty miles further south ("Colonel Blake's," of Conrad), in the sections exhibited by the Calvert Cliffs, and in the Perna beds on both banks of the Patuxent River. There is, further, strong, although not conclusive, evidence for considering the beds containing *Perna maxillata* and *Ostrea percrassa* as the lowest of the series.

The following tables exhibit as nearly as possible the distribution of Lamellibranchiata in the deposits of both periods, those of the newer being for convenience of comparison divided into the Patuxent and St. Mary's groups:

Older Period.

1 Arca dipleura,
(= A. calilpleura ?),
2 " Marylandica,
3 " subrostrata,
4 " triquetra,
5 Artemis acetabulum,
6 Astarte varians,
7 " exaltata,
8 Cardium craticuloides,
9 " leptopleura,
10 Corbula idonea,
11 " elevata,
12 Crassatella melina,
13 " turgidula,
14 Cytherea subnasuta,
15 Isocardia Markoei,
16 Leda liciata,
17 Lima papyria,
18 Lucina Foremani,
19 " subplana,
20 " *crenulata*,
21 Mytilus incurva,
22 Modiola Ducatelii,
23 Ostrea percrassa,
24 Panopæa porrecta (Goldfussi),
25 Pecten Humphreysii,
26 " Madisonius,
27 Pectunculus parilis,
28 " lentiformis,
29 Perna maxillata,
30 Pholas ovalis,
(= *P. costata ?*)
31 Tellina lenis,
32 Venus alveata,
33 " staminea,
34 " *Mortoni ?*

Newer Period—I. Patuxent Group.

1 Anomia Conradi,
(= *A. ephippium ?*),
2 Arca idonea, St. M.
3 Artemis acetabulum, St. M.
4 Astarte undulata, St. M.
5 Cardita protracta,
6 Cardium laqueatum, St. M.
7 Corbula idonea, St. M., E.
8 Crassatella Marylandica, E.
9 Cytherea Sayana, St. M.
10 " Marylandica,
11 " albaria,
12 Isocardia fraterna, St. M.
13 Lucina Americana, E.
14 Mactra incrassata,
15 Mya producta,
16 *Panopæa Americana*,
17 Panopæa porrecta (Goldfussi), St. M.
18 Pecten Madisonius, St. M., E.
19 Petricola centenaria,
20 Pholas ovalis,
(= *P. costata ?*), St. M.
21 Tellina biplicata, E.
22 *Venus Mortoni ?* St. M.

II. St. Mary's Group.

1 Amphidesma carinata,†
2 " subovata,†
3 Arca idonea,
4 " arata,†
5 " stilicidium,†
6 Artemis acetabulum,
7 Astarte undulata,
8 " planulata,†
(= A. perplana ?),
9 " vicina,†
10 Cardita granulata,†
11 Cardium laqueatum,
12 Corbula inequalis,†
13* " cuneata,†
14 " idonea,
15 Cytherea Sayana,
16 Artemis concentrica,†
(= *A. elegans ?*),
17 Isocardia fraterna,
18 Lucina cribraria,†
19* Mactra ponderosa,†
20 " subcuneata,†
21 " fragosa,†
22 " delumbis,†
23 *Ostrea Virginica*,†
24 Panopæa porrecta,
25 Pecten Madisonius,
26 Pholadomya abrupta,†
27 Pholas arcuata,
(= *P. costata*),
28 *Saxicava rugosa*,†
29 *Solen ensis ?* †
30 Venus alveata,
31 " *Mortoni*,
32 " tetrica,†
33 " *mercenaria*,†
34 " inoceriformis.†

NOTE.—The italicized names represent species considered to be identical with living forms; those (in the Patuxent group) followed by the letters St. M. and E., species common to St. Mary's and to Easton (Choptank River); and those (in the St. Mary's group) followed by a †, species peculiar to the locality.

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* *Corbula cuneata* and *Mactra ponderosa* are also found in the newer deposits of Calvert County, near Cove Point.

A comparison of the foregoing lists will show at a glance, that of the thirty-four bivalves belonging to the older formations, *at most* only three (or 9 per cent.) are found to be living forms (*Pholas ovalis* [= *P. costata?*], *Lucina crenulata* and *Venus Mortoni*), and that only six (18 per cent.) and seven (21 per cent.) are common respectively to the Patuxent and St. Mary's exposures, viz.:

To Patuxent.	*To St. Mary's.*
Artemis acetabulum,*	Artemis acetabulum,
Corbula idonea,	Corbula idonea,
Pholas ovalis,*	Pholas arcuata (= costata),
Panopæa porrecta,	Panopæa porrecta,
Pecten Madisonius,	Pecten Madisonius,
Venus Mortoni,	Venus Mortoni,
	" alveata.*

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* There appears to be much confusion regarding the species of *Artemis* found fossil in the Atlantic Tertiary deposits, and their relations to the forms now living on the Florida coast. In 1832 ("Fossil Shells of the Tertiary Formations," p. 20) Conrad characterized the species *A. acetabulum*, which appears to have been until then confounded with the *A. concentrica*, Con., *non* Born (*A. discus*, Reeve, "Conchologia Iconica," vol. vi, sp. 9), inhabiting the southern coast. No mention is there made of its being found also in a recent state, but subsequently, 1838 ("Fossils of the Medial Tertiary Formation," p. 29), we find the following statement: "This fine species is very common in the localities named, and also occurs recent on the Florida coast." In the list of shells inhabiting the Florida coast, prepared by the same author in 1846 (A. J. Science, 2d series, ii, p. 393), only two species of *Artemis* are catalogued, *A. elegans* and *A. concentrica*, and it therefore appears highly probable that the statement considering *A. acetabulum* also as a living form was founded on a misconception, the more especially, as an examination of the recent shells in the Museum of the Academy of Natural Sciences fails to reveal anything answering to Conrad's original description. This species may possibly prove to be identical with (or only a variety of) the *Venus concentrica* described by Tuomey and Holmes in their work on the Pliocene fossils of South Carolina (1857, p. 82), and to which Conrad applied the specific name of *intermedia* (*Dosinia* [*Artemis*] *intermedia*) in his check list of Miocene fossils (Proc. A. N. S., 1862, p. 575). The *A. acetabulum* is found fossil in the Tertiary deposits of Maryland, Virginia, North Carolina and South Carolina, and must be carefully distinguished from the *A. concentrica* of Born, to which it bears only a distant resemblance. Another fossil species is probably the *A. elegans*, Con. (living on the Florida coast); one almost perfect specimen, which agrees in all essential respects with the recent forms, is in the Academy Miocene collections, but, unfortunately, the locality whence it was obtained is not given. In his account of the geology and organic remains of the peninsula of Maryland (1830, J. A. N. S., vol. vi, p. 212), Conrad mentions the *Cytherea* (*Artemis*) *concentrico*, Lam., as occurring in the St. Mary's exposure, but as subsequently ("Fossils of the Medial Tertiary," 1838, p. 30) it is distinctly stated that the same does *not* occur in the Miocene formation, it is highly probable that the original observation was erroneous. Certainly nothing corresponding either to the species in question or to *A. discus* is to be found in the Maryland Miocene collection of the Academy.

The common species inhabiting the southern coast is *not* the *A. concentrica* of Born, with which it has been frequently confounded, and to which it bears only a slight resemblance, but the *A. discus* of Reeve (*loc. cit.*). A third species, the *A.* (*Dosinia*) *Floridana*, Con., is unquestionably very closely allied to the first, from which it differs essentially only in the greater obliquity of the pallial sinus. In other respects it agrees with the figures and minute description of Born's species as given by Agassiz in his "*Iconographie des Coquilles Tertiaires*" (*Nouv. Mém. de la Société Helvétique*, 1845, vol. vii).

It is not improbable that the various forms of *Venus alceata* and *V. latilirata* are mere varieties of one and the same species, a series of intermediate stages seeming to link them together. The *V. athleta*, constituted by Conrad to embrace the *V. athleta* of Say, *V. latilirata* of Tuomey and Holmes, and the *V. paphia* of Lamarck, is also a very closely related, if not identical, form. The *V. alveata* is included by Stimpson among the living mollusca of the Atlantic coast (Smithsonian Check Lists, 1860), but this fact appears very doubtful in the opinion of Tryon ("American Marine Conchology," 1873, p. 160). It must be confessed, however, that there exists a very striking agreement between the fossil shell and specimens of the *V. paphia*, Linn., from St. Thomas, the main difference being a tendency on the part of the latter to lose the full solidity of its ribs some distance before they reach the posterior slope. The *V. alveata* exhibits a similar tendency, but not quite to the same extent.

I have been unable to discover any description of the *Pholas ovalis*, Con., nor is there any mention made of it either in the Miocene check list prepared by Conrad in 1862 (Proc. A. N. S.), or in that of Meek of 1864 (Smithsonian Miscell. Collections). I have, therefore, only doubtfully referred it to *P. costata*.

Deducting two or three species that are also found at Easton, we still have left twenty-three (or 68 per cent. of the whole number) that are not found in the later deposits.

On the other hand, the fossils of the newer deposits as exhibited in the sections on the west bank of the Patuxent show a very decided similarity to those of St. Mary's, for out of the twenty-two species of bivalves occurring there, no less than eleven (or just 50 per cent.) are also common to the last mentioned locality. There can, therefore, I believe, be no reasonable doubt that the deposits exposed on the Patuxent River immediately above the *Perna* beds constitute a direct continuation of the highly fossiliferous strata bordering both sides of the St. Mary's River. These last number among their fossil fauna also about thirty-four species of Lamellibranchs, the same number as is found in what we have designated as the older group, but of these thirty-four, about twenty two (or, deducting *Corbula cuneata* and *Mactra ponderosa*, twenty), or 65 per cent. are peculiar to the locality. Moreover, of the entire number, about seven (or 20 per cent.) are still living on the Atlantic coast. The dissimilarity of the two faunæ cannot fail to strike the least observant investigator, and Conrad has dwelt at some length upon this curious manifestation (A. J. Science, vol. xxviii, p. 282, and Bull. National Institution, 1841, p. 176). That paleontologist, singularly enough (apparently not having made any exact numerical estimates either of the living forms, or of the forms found in one locality and not in the other), explains the differences as due solely to variable local conditions.* This interpretation might very satisfactorily account for the phenomenon as far as generic distribution alone is concerned, and, indeed, it would even hold good in its bearings on a limited number of species, but it would hardly apply to a case such as the present one, where the specific dissimilarity is so vast in such a comparatively very limited geographical extent.

Now, if the supposition that the deposits in question were deposited at two different periods be a correct one, and paleontological evidence goes far to prove that they were, we should naturally expect to find also some direct stratigraphical evidence afforded by the superposition of the strata themselves.* The following section was obtained by Conrad at a point on the Chesapeake, near "Beckett's," about twenty-eight miles south of Fair Haven:

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* Thus he states (A. J. S., *loc. cit.*): "If our coast were now suddenly elevated, we should find spots where the shells would consist chiefly of an immense number of *Modiola demissa* mixed with *Littorina littorea* and *Melampus bidentatus;* these are found on the margin of the lagoons at high-water mark, the *Modiola* imbedded in a tenacious soil. At a little distance would be found *Venus mercenaria*, *Mya arenaria*, *Solen ensis*, *Solecurtus Caribeus;* among these would be *Ostrea Virginiana*, *Fusus cinereus*, and a few of *Pecten concentricus*. Such is the group existing on the sandy shore of the Estuaries. Hard by, would be a vast deposit of oyster shells with *Echinus*, and immense masses of *Serpula*. These live on the bottom of the lagoons, which is composed of a mixture of sand and mud. Then would be found another group of shells which live only in deep water, the *Astarte lunulata*, *Nucula limatula*, *N. proxima*, *Cardita borealis*, *Pholas costata*, in company with great numbers of *Mytili*. This deposit we should recognize as having been formed in harbors, like those of Newport and Charleston. . . . "

It will be observed that in the above conception Conrad has confined himself entirely to generic and not specific distribution.

Feet in thickness.	
5	Sand, without shells.
3	Sand, with innumerable shells.
20	Mingled sand and clay, without fossils, or very rare.
3	Same as below, less numerous.
4	Sand and clay, with a group of shells like that at Hance's.

The shells obtained at Hance's, about four miles further north, were the following:

Bivalves.

Astarte varians,
" exaltata,
Artemis acetabulum,
Arca subrostrata,
" dipleura,
Cytherea subnasuta,
Cardium leptopleura,
Crassatella melina,
Corbula idonea,
" elevata,
Isocardia Markoéi,
Lima papyria,
Lucina Foremani,
" subplana,
Lucina crenulata,
Pectunculus lentiformis,
Venus latilirata,
" Mortoni?
" staminea.

Univalves.

Bonellia lineata,
Cancellaria biplicifera,
" engonata,
Dentalium thalloides,
Fissurella Marylandica,
Voluta mutabilis,
Infundibulum perarmatum,
Marginella perexigua,
Pleurotoma Marylandica.
" bellacrenata,
Scalaria pachypleura,
Solarium trilineatum,
Sigaretus fragilis,
Trochus peralveatus,
Turritella indenta,
" exaltata,
" perlaqueata,
Voluta solitaria.

It will be at once noticed that in addition to the lowest fossiliferous stratum, extending to about seven feet above water level, a second highly fossiliferous one manifests itself at a height of about twenty-seven feet, in which were recognized among other shells *Artemis acetabulum* and *Pecten Madisonius*. The mineral character of this upper deposit is described by Conrad as being a "quartzose sand, very incoherent," which is exactly what we meet with in the arenaceous deposits on the west bank of the Patuxent River, near Benedict, and which we have identified as equivalents of the St. Mary's deposits. They are described by Conrad as being composed of an "arenaceous, fossiliferous stratum," the sand of which is "quartzose and incoherent" (B. N. I., p. 185).

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* It may as well be remarked, that, although in the foregoing examination of the molluscan fauna I have dwelt exclusively upon the *Lamellibranchiata*, the *Gasteropoda* offer equal, if not greater support to the general conclusion arrived at. On comparing the lists of geographical distribution given by Conrad in the Bulletin of the National Institution (pp. 181–7), it will be seen that not a *single* recent form occurs among the eighteen enumerated from the Calvert cliffs at "Hance's"; and further, that only two species, *Voluta mutabilis* and *V. solitaria*, are common to the forty-two found at St. Mary's. Of these last eight (or 19 per cent.) were considered by Conrad to be recent forms:

Buccinum trivittatum,
" lunatum,
Buccinum quadratum,
Natica heros,
Natica duplicata,
Dentalium dentalis,
Fusus cinereus,
Scalaria clathrus.

Nearly all the species found on the west bank of the Patuxent also occur at St. Mary's, and the same can be said of those collected in Calvert county near Cove point, the southern extremity. Singularly enough, that although three species of *Turritella*—*T. indenta*, *T. exaltata*, and *T. perlaqueata*—were collected from Calvert cliffs in the upper portion of the county, none of them appear to have been found near Cove Point, where "vast quantities" of a new species, *T. plebeia*, "the common species of St. Mary's River" (loc. cit., p. 182), appear suddenly to make their appearance.

We have thus exposed in one section two highly fossiliferous strata, the upper of which shows a very decided analogy to what we have designated as the newer group, and the lower of which assumes a distinct personality for reason of its position, and the paleontological characters impressed upon it. Proceeding from this point southeastward, and therefore in the general direction of the dip of the beds, we should naturally expect to meet a point where our upper stratum, or its equivalent, would descend nearer to the level of the Bay, and in fact we do find just such a point near Cove Point, where "the group most characteristic of these Tertiary deposits, imbedded in sand," descends to a height only about fifteen feet above water mark (B N. I, p. 183). The fossils found here are also nearly all found at St. Mary's, and they are, moreover, "highly ferruginous, as much so as many of the crag fossils of Great Britain, which they greatly resemble, also, in other respects" (Conrad, *loc. cit.*). On the St. Mary's River, the southeasternmost extension of the formation, the same deposit sinks almost to water level, as might well be expected on following the general direction of the dip. Here, the newer deposits, well characterized by their fossils, make their appearance.

On proceeding from our first point almost due northwards, and therefore at a considerable angle to the line of strike, we meet with just the reverse phenomena met with on our southern journey. At Fair Haven, where Conrad obtained the following section—

Feet in Thickness.	
50	Whitish Clay.
	Bones of Cetacea.
3	Clay, with siliceous casts of marine shells and fragments of bones.
5	Clay, with *Ostrea percrassa*, *Pecten Humphreysii*.

the highly fossiliferous stratum found at water mark at Beckett's is probably represented by a bed of clay three feet in thickness, commencing at a height of five feet, and which contains "great numbers of black, water-worn, siliceous casts of small shells, chiefly *Turritella*, the species not yet determined." Below this an entirely new deposit now makes its appearance, a bed of clay of five feet thickness, characterized by *Ostrea percrassa* and *Pecten Humphreysii*. This last, therefore, probably represents the most ancient post-Eocene deposit exhibited on the Chesapeake. *Ostrea percrassa* and *Pecten Humphreysii* were also found by Conrad at Huntingtown, Calvert County, where in a "*depression or small valley*" a race-way had been excavated through the fossiliferous "marls." The lowest member of the section was "quartzose sand, with casts of *Perna maxillata*." On the east bank of the Patuxent River, moreover, near the mouth of St. Leonard's Creek, Conrad observed innumerable casts of *Perna maxillata* imbedded in a stratum of fine siliceous sand, and resting on the fragmentary rock considered by him as the "foundation of the peninsula" (B. N. I., p. 184).

We should naturally look for some deposit contemporaneous with that occurring on the west bank of the Patuxent, at some point northeast of that locality where a section may present itself. This we find at Easton, on the Choptank, where the molluscan fossil fauna corresponds very closely with that observed on the former river. The deposits of the older period, on the other hand, reappear in Cumberland County, New Jersey, in the "Miocene marl" of Shiloh, containing the following assemblage of fossils (Cook, "Geology of New Jersey," 1868, p. 297):

Bivalves.

Ostrea Mauricensis,
" percrassa,
Plicatula densata,
Carditamera aculeata,
" arata,
Crassatella melina,
Astarte Thomasii,
Venus Ducatellii,
Periploma alta,
Corbula elevata,
Saxicava myæformis.

Four species of the above are also found in Maryland, three of which, *Ostrea percrassa*, *Crassatella melina*, and *Corbula elevata*, are found, I believe, exclusively in the deposits designated as those of the older period. None are recent forms.*

The small percentage of living forms occurring in the "older deposits," as compared with that of the "newer," leaves little doubt for the inference that the deposits in question were formed at two different periods, the latest of which clearly belongs to the Miocene. A comparative examination of some of the peculiar fossil forms of the older deposits, together with the extremely low percentage of living forms, would seem to indicate an age as nearly Oligocene as Miocene, although perhaps not a single Eocene species is represented. This last fact need not surprise us, however, as the relationship of the Oligocene to the Miocene appears to be greater in almost all the localities of its representation than to the Eocene. The Eocene, moreover, of Maryland is represented only by a very limited number of fossils, and Conrad, himself, has called attention to the fact, that there appears to exist a greater amount of difference between the Eocene and Miocene formations than obtains between the Secondary and Tertiary, or between the Devonian and Carboniferous systems (B. N. I, p. 177). The following comparison may serve to throw some light upon the relative age of the deposits in question:

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* *Ostrea Mauricensis* may prove to be only a variety of the *O. Virginica.*

PERNA MAXILLATA, Lam.

This species agrees thoroughly with the figure and description of the same given by Goldfuss in the "Pectrefacta Germaniæ" (vol. ii, p. 106), and to which the locality Weinheim (Oligocene) is assigned. The sub-Apennine species, formerly classed under the same name, is considered by Deshayes to be distinct, and he has applied to it the specific name of *Soldanii* (Lamarck, "*Animaux sans Vertèbres*," 2d ed., vol. vii, p. 79). A second species of *Perna*, the *P. Sandbergeri*, Desh., also occurs in the Oligocene locality of Weinheim (Sandberger, "*Conchylien des Mainzer Tertiärbeckens*," p. 367).

MYTILUS INCURVA, Conr.

This large species of *Mytilus* may perhaps be taken as the representative of *M. Haidingeri*, Hörnes ("*Die Foss. Moll. des Tertiärbeckens von Wien*," *Abhand. d. k. k. geolog. Reichsanstalt*, iv, p. 356), found both in the Oligocene (Eggenburg) and Miocene divisions of the Vienna basin. Rolle (*Sitzungsberichte d. k. Akad. d. Wissenschaften*, 1859, p. 64) and Sandberger consider the *M. Haidingeri* as the equivalent of *M. Faujasi*, Brongn., occurring at numerous Oligocene localities of the Vienna and Mentz basins.

ISOCARDIA MARKOEI, Conr.

This *Isocardia* is, it appears to me, erroneously referred by Hörnes (*loc. cit.*, p. 165) to the *I. cor*, L., from which it is very readily distinguished by its relatively much greater height, and greater development of the umbones. It is a singular fact that this species of *Isocardia* was followed in the later period by the *I. fraterna*,* Say, which is barely distinguishable from fossil examples of the *I. cor* from Italy and Sicily.

It is worthy of remark, that Rolle (*loc. cit.*, p. 81), as early as 1859, only four years after Beyrich first applied the term Oligocene to some of the middle Tertiary deposits of northern Germany, hinted at the possible existence of the same formation on the banks of the Patuxent, his conclusions being drawn from an examination, among other fossils, of specimens of *Lucina anodonta*, Say, *Arca idonea*, Conr., and *Cardium laqueatum*, Conr.

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* On comparison with specimens from the English Crag this species will be found to differ very broadly from the *I.* (*Cyprina*) *rustica* of Sowerby, with which it has been confounded.

IV.

ON THE OCCURRENCE OF NUMMULITIC DEPOSITS IN FLORIDA, AND THE ASSOCIATION OF NUMMULITES WITH A FRESH-WATER FAUNA.*

Beside the so called *Nummulites Mantelli* of Morton (Synopsis Org. Rem. Cretac. Group, p. 45, 1834), a species now known to belong to the genus *Orbitoides*, only one other form of supposed Nummulite has been recorded as occurring fossil in any North American formation. This is the *Nummulites Floridanus* from the "upper Eocene limestone" of Tampa Bay, Florida, described by Conrad in Vol. II (new series) of the "American Journal of Science and Arts" (1846). The species is there said to be abundant, and is referred to the subgenus *Assilina*† of d'Orbigny. The description given is brief, but at the same time very broad, and no reference of any kind is made to the internal chambers or the partitions of the test; nor does the figure appended to the description, which resembles a Nummulite only in the circumferential outline, give the faintest indication of these characters. In fact, if Conrad's figure is at all carefully drawn, it would much more nearly indicate a species of the genus *Orbiculina* than of *Nummulites*. In the "Catalogue of the Eocene Annulata, Foraminifera, Echinodermata, and Cirrepedia of the United States," prepared by the same author (Proc. Acad. Nat. Sciences of Phila., vol. 17, p. 74, 1865), the form in question (*Cristellaria? Floridana* of d'Orbigny, *Prodrome de Paléontologie*, vol. ii, p. 406) is referred to the new genus *Nemophora* of Conrad, the characters of which are not stated, and whose relations to *Nummulites*, if any such exist, are left to the imagination of the reader to determine.‡ In numerous specimens of rock fragments that have been kindly furnished from different parts of the State of Florida by Dr. Eugene A. Smith, State Geologist of Alabama, and Mr. Joseph Willcox, of this city, the writer has carefully searched for foraminiferal remains that might with any amount of positiveness be identified with the form above referred to, but without success. While the *Operculina* (*Cristellaria!*) *rotella*, stated by Conrad (*loc. cit.*) to occur with the so-called Nummulite, was found in sufficiently great abundance in some of the rock fragments—in fact, largely entering into the composition of their incoherent masses—no trace of anything answerable to the latter could be detected, unless certain associated disciform bodies, measuring a quarter of an inch or more in diameter, and ornamented on the external surface with regular concentric lines of prominent granules, were actually the objects sought after.* But in these the spiral volutions represented by Conrad could not be detected, nor does the author make reference in his species to any external ornamentation consisting of granules. On the whole, we believe, it may be safely affirmed that the *Nemophora* had nothing in common with the genus *Nummulites* beyond a resemblance in outline, and the general community of character that would place all similar organisms in the one class of the foraminifera. The existence, therefore, of any fossil North American Nummulites may be considered to have been thus far at best but very doubtful.

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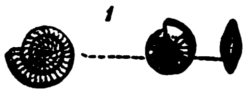
* The author has for various reasons preferred leaving this article as it originally appeared in the Proceedings of the Academy of Natural Sciences of Philadelphia, for July, 1882. A supplementary note has been added covering more recent observations.

† By some authors the members of this group are considered to have distinctive characters sufficient to separate them as a genus apart from *Nummulites* (La Harpe, *Étude sur les Nummulites du Comté de Nice*, Bulletin de la Soc. Vaud. des Sc. Nat., vol. xvi, p. 211, 1879).

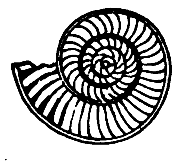
‡ As is the case with a very large proportion of Conrad's genera, no diagnosis of the "genus" *Nemophora* appears ever to have been furnished; at least, it has not been the good fortune of the writer to discover any such.

But whatever doubt may have hitherto existed as to the occurrence of North American Nummulites, none such can any longer remain. From an examination of rock specimens that were recently obtained by Mr. Willcox from the western shore of the peninsula of Florida. the writer has been enabled to determine positively not only the existence there of these organisms, but their occurrence (locally) in such quantities as to constitute by their masses a true nummulitic rock. The rock in question is a white or yellowish white friable limestone, found in the immediate neighborhood of the Cheeshowiska River, Hernando County, a few miles (4) from the coast line. The rock whence the fragments were obtained occupies a level not more than two feet above tide-water of the Gulf. All the specimens of Nummulites appear to belong to a single species, and to the sub-genus *Nummulina*, in which, as distinguished from *Assilina*, the individual whorls completely envelop each other, and to which the most characteristic foreign representatives of the genus—*N. lævigatus*, *N. complanatus*, *N. planulatus*, *N. intermedius*, etc., belong. The tests, varying in size up to about ⅓ inch in diameter, are in an excellent state of preservation, and may be readily sliced open so as to show the internal structure. A central initial chamber is distinctly visible. To this species, belonging to the group of the *plicatæ* of D'Archiac, I would propose, from the name of its discoverer, the specific designation of *N. Willcoxi*.†

1



2



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* These bodies appear to represent a new form of foraminiferal test, but their imperfect preservation precludes the possibility of a satisfactory diagnosis.

† *Nummulites Willcoxi:* Test regularly rounded, tumid (more especially in the earlier stage), and measuring in the largest specimen about ⅓ inch in diameter; external surface distinctly marked by the arcuate, and somewhat wavy outlines of the septal prolongations; volutions about 5, completely enveloping; septa close set, about 35–45 in the last whorl, and well flexed; central initial chamber distinctly visible.

While on further investigation this species may be found to be identical with one of the numerous forms described from the nummulitic deposits of Eur-Asia, from several of which it scarcely appears to differ, yet in the absence of actual specimens with which to institute direct comparisons, and the difficulty that attaches to the specific determination of this class of organisms, I have preferred to follow the safer course, and to describe it as distinct. According to Carpenter, Kitchen Parker and Rupert Jones, all the various "specifically distinct" forms described as belonging to the subgenus (or genus), *Nummulina*, of which, up to 1853, 55 were recognized by D'Archiac and Haime, are referable to a single species, which is consequently co extensive with the genus (Carpenter, "Introduction to the study of the Foraminifera," Ray Soc. Rep., 1862, pp. 273–4).

As to the age of the formation represented by these nummulitic deposits, there might appear to be at first sight no question of doubt. The presence alone of Nummulites in any formation is almost positive indication as to the Eocene or Oligocene age of that formation, and the more especially when the remains of these organisms occur in any abundance.[*] Admitting the supposition of this age, we should naturally look to the associated fossils for further confirmatory evidence bearing on this point. Singularly enough in the case of the Florida nummulitic rocks—at least in the fragments that have been placed at my disposal—with very few exceptions all the molluscan remains belong to a period much more recent than the Eocene, and to species that are still living at the present day. And what may appear still more singular, they are referable in principal part to land and fresh-water genera—*Glandina*, *Paludina*, *Ampullaria*.[†] From this association, and the circumstance that Nummulites are still met with in existing seas,[‡] it might readily be inferred that there has been here a co-mingling of contemporaneous marine and fresh-water organisms, and that the deposits in question were laid down under such conditions—proximity to the mouth of a river—where a co-mingling of this kind could take place. Indeed, it would be difficult from paleontological evidence alone to disprove such an assumption, were it not that almost incontrovertible proof to the contrary, in addition to that furnished by the *abundance* of Nummulites, is afforded in the presence of the remains of *Orbitoides*,[§] a genus which attained its greatest development in the upper Eocene ("Nummulitic") and Oligocene periods, and which does not appear to have survived the Miocene. There can, therefore, be little or no doubt that the rock fragments marked by this admixture of an older and newer (post-Pliocene or recent) fauna, and comprising both marine and fresh-water types of organisms, have derived their faunal characters in great part from the deposits of a more ancient formation, which formation represents, and is the equivalent of, a portion of the European "Nummulitic" (whether Eocene or Oligocene). The exact locality or localities which these Florida nummulitic deposits occupy *in situ* has not yet been ascertained, but it is fair to assume that the beds lie along the Gulf border (possibly in great part submerged), where, through the disintegrating action of the oceanic surf, their fragments have at a comparatively recent period been washed together with the material that at the same time was being carried out by the fresh-water streams. The precise position which the formation holds in the nummulitic scale as fixed by Hantken or La Harpe (*Études sur les Nummulites du Comté de Nice*, Bull. de la Soc. Vaud. des Sc. Nat., vol. xvi, pp. 223–4, 1879), cannot be positively determined from our present data, since exceptionally the group of the *Nummulites plicatæ* is represented as well in the oldest as in the newest of the Tertiary deposits marked by the members of this class of organisms.

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[*] Nummulites are excessively rare in deposits newer (Miocene or Pliocene) than the Oligocene.

[†] The recent species *Glandina parallela*, *Paludina* (*Vivipara*) *Waltonii* (Tryon), and *Ampullaria depressa* have been identified by Mr. Tryon.

[‡] Very rare; all the forms are referable to the type *N. planulatus* (Carpenter, *op. cit.*, p. 275; Zittel, *Handbuch der Paläontologie*, vol. 1, part 1, p. 100, 1876), of the same group (*plicatæ; radiatæ* of Carpenter) to which *N. Willcoxi* belongs.

[§] Resembling in outline the European *O. ephippium*.

FIGURES. *Nummulites Willcoxi.*
1, Natural size; 2, Same, enlarged.

NOTE.—Mr. Joseph Willcox has more recently found the *Nummulites Willcoxi*, Heilpr., *in situ*, in rock masses situated some fifteen miles to the northeast of the locality on the Cheeshowiska River, whence the species was originally described, and at an elevation of not less than 150 feet above the level of the sea. The existence of a true nummulitic basement formation in the State of Florida is thus placed beyond question, and, doubtless, the same will be found to have a very considerable extension inward. A second and very much larger form of Nummulite, measuring between one-third and one-half of an inch in diameter, occurs associated with the *N. Willcoxi*; in it the whorls expand very rapidly in size, and the septa, in addition to being comparatively more numerous, are considerably more flexed than in the commoner species. Among other foraminiferal remains, not hitherto recognized, I believe, as occurring in the United States Tertiaries, which I have been enabled to detect in the Hernando County rocks, are individuals belonging to the genera *Heterostegina*, *Sphæroidina*, *Biloculina* (?), *Triloculina*, *Quinqueloculina*, and *Spiroloculina*. The genus *Orbitoides* is very abundantly represented in two or more species, one of which, the *O. ephippium* (*O. sella*), appears pre-eminent for its large size. The great development of this species, irrespective of all other evidence, would almost be sufficient of itself to determine the age (Oligocene) of the rock formation in which it occurs.

V.

A COMPARISON OF THE TERTIARY MOLLUSCA OF THE SOUTHEASTERN UNITED STATES AND WESTERN EUROPE IN RELATION TO THE DETERMINATION OF IDENTICAL FORMS.

The study of the fauna, whether extinct or living, of any country resolves itself into two distinct methods of investigation, the general and the comparative. In the general method we look upon an assemblage or community of animal forms as constituting an integral part of the country it characterizes, and then we consider it only in relation to that country and to itself (the animal forms *inter se*). In the second or comparative method we no longer regard this community as constituting a whole or unit, but merely as a part of a more extensive community, and we now view it in the relation of a part to a whole. This comparative system of investigation, which, it will be manifest, involves a thorough general acquaintance with all or most extraneous faunæ as well as the one under special consideration, is one of great difficulty, and one that requires more than an ordinary amount of acumen in its pursuit, for in the broad facts of geographical distribution are connected some of the profoundest biological and physical problems. The study of comparative or geographical zoology constitutes one of the essential factors of biological science, for without a true understanding of the general affinities of scattered groups of animals our conception of the organic universe would be one of disjointed parts instead of a continuous whole. We know, in fact, little of a whole unless we comprehend its relation to its component parts, and *per contra*, we know little of a part unless we understand the relation it bears to the whole.

The subject of geographical distribution in its bearings on geology, whether considered in its broader sense as pertaining to groups, or in the more limited sense as pertaining to the individuals composing those groups, cannot be over-estimated. It is by the recurrence over broad or scattered areas of certain related animal types, and frequently even over the most remote areas of identical specific forms, that the paleontologist is enabled to arrange and classify his strata. One single well-determined fossil will, in the absence of further data, frequently determine approximately, and sometimes exactly, certain geological horizons, and although, perhaps, in most cases it would still be impossible from the correspondence or divergence of organic forms to determine with *absoluteness* how closely in the matter of time two or more geological formations may be connected with, or separated from, each other, yet in the identity of such forms alone are we afforded the means of making a near comparison. The correct determination, therefore, of all organic remains is a matter of the greatest importance.

Unfortunately for the development of the science, the doctrine that identical specific forms cannot, or ought not, occur over widely separated areas has taken root in the minds of a few of the most eminent scientific investigators, the baneful effects of whose authority in relation to this special line of research will be encountered by the student at almost every step in his investigations. The science of geographical paleontology, at least as far as the invertebrata are concerned, may be said to be in this country still in a state of infancy, a circumstance partly due to the limited number of workers in the field, and partly to the influences just stated.

I have endeavored in the following pages to summarize as nearly as possible the results obtained from a series of comparisons between the Tertiary mollusca of Western Europe and those of the Southeastern United States, undertaken with the view of determining with a certain amount of precision the number of identical and very nearly related species. My comparisons were in a number of cases made between actual specimens, and those mainly determined in the localities to which they belong; where no specimens could be obtained I was compelled to content myself with the various analyses of the descriptions of figures afforded by the works of the most competent authorities. The result shows a far greater intimate relationship to exist between the two faunæ than one might have been led to suppose from an examination of the lists that have heretofore been published.

EOCENE.

In the "Check List" of Mr. Conrad, published by the Smithsonian Institution in 1866, only about five species are enumerated as common to the Eocene deposits of both shores of the Atlantic, viz.: *Ostrea* (*Gryphostrea*) *eversa*, Deshayes; *Cardita planicosta*, Lam.; ? *Phorus* (*Onustus*) *extensus*, Sow.; *Hippocrenes columbaria*, Defr., and (!) *Voluta* (*Volutilithes*) *mutata*, Desh. In addition to these Conrad enumerated in 1833 ("Fossil Shells of the Tertiary Formations," p. 34) the following: *Solarium patulum*, Lam.; *S. canaliculatum*, Lam.; *Bulimus* (*Niso*) *terebellatus*, Lam.; *Sigaretus canaliculatus*, Sow.; *Calyptræa* (*Trochita*) *trochiformis*, Lam.; *Pyrula tricarinata*, Lam.; *Avicula trigona*, Lam.; *Cytherea erycinoides*, Lam.; *C. suberycinoides*, Desh.; *Corbis lamellosa*, Lam., and *Fistulana elongata*, Desh., most of which on examination prove to be as well American as European forms. In the Appendix to Morton's Synopsis ("Synopsis of the Organic Remains of the Cretaceous Group," 1834) only six European species are recognized as occurring in the American formation: *Solarium canaliculatum*, Lam.; *S. patulum*, Lam.; *Bulimus terebellatus*, Lam.; *Cardita planicosta*, Lam ; *Corbis lamellosa*, Lam., and *Fistulana elongata*, Desh. In the list published by Conrad in 1846 (Amer. Journ. Science, 2d ser., vol. i, p. 219), of the preceding enumerations only two species are retained as being "analogous" to trans-Atlantic forms, *Cytherea Mortoni*, Con. (*Cytherea erycinoides*, Lam., and *C. suberycinoides*, Desh.) and *Avicula limula*, Con. (*A. trigona*, Lam), but in addition we have five new ones catalogued: *Cardita Blandingi*, Con. (*C. acuticosta*, Lam.), *C. rotunda*, Lea. (*C. asperula*, Desh.); *Cardium Nicolleti*, Con. (*C. semigranosum* [—*granulatum*], Sow.); *Turritella Mortoni*, Con. (= ?), and *Rostellaria laqueata*, Con. (*R. fissurella*, Lam.). Finally, all species considered identical prior to 1866 are rejected as such with one exception (*Cardita planicosta*) in the Smithsonian List. The reasons for so doing, which, in the majority of cases, I believe, are not stated, appear to me incomprehensible.

In the introduction to his "Contributions to Geology," 1833, p. 19, Mr. Lea states that he is "not perfectly satisfied that a single species is strictly analogous to those from the Eocene Period of Europe . . . . .," but in a note (pp. 207, 208) makes the following comparisons: *Pasithea umbilicata*, Lea, with *Bulimus terebellatus*, Lam.; *Venericardia rotunda*, Lea, with *V. squamosa*, Lam.; *Pectunculus obliqua* (*uus*), Lea, with *P. nanus*, Desh.; *Ostrea divaricata*, Lea, with *O. flabellula*, Lam.; and *Solen Blainvillii*, Lea, with *Solen effusus*, Lam.

In the "Proceedings" of the Academy of Natural Sciences of Philadelphia for 1879 (pp. 217–25) I have instituted a number of comparisons between American and European Eocene forms, which are here reproduced with emendations and additions; and in the same journal for 1884 (pp. 104–12) Dr. Otto Meyer identifies a few additional species. The list herewith appended will, I trust, materially increase our knowledge of the interesting subject of relationship and geographical distribution.

OSTREA COMPRESSIROSTRA, Say. Journ. A. N. S., iv, p. 132.

It appears to me very doubtful whether the character of the beaks pointed out by Say (J A. N. S., iv, p. 133) to distinguish this species from the *O. Bellovacina*, Lam., is a constant one or not, and I have therefore some hesitation in recognizing the form as a distinct species. The beaks of *O. compressirostra* certainly do appear more compressed than is indicated in the majority of figures representing the European oyster, but at least some of the specimens in the Academy's collection of *O. Bellovacina* (*var. edulina*), from the "London Clay" of Bognor, have the beaks undistinguishable from those of the American species.

The want of specimens with which to make the proper comparisons, and the difficulties that attach to the determination of the species of *Ostreidæ*, prevent me from expressing a definite opinion as to the relationship of the two forms, although I strongly incline to the opinion that they are only varieties of one and the same species. The figures of *O. Bellovacina*, as given by S. Wood in his monograph of the Eocene Mollusca (Palæont. Soc. Reports, 1861, pl. vii, figs. 3, *a*, *b*, *c*), accord almost perfectly with the American oyster. The oyster found by Lyall in the "Grove," about 17 miles north of Charleston, S. C., and which appeared to him "undistinguishable from *O. Bellovacina*" (Journ. Geol. Soc. London, i, p. 433), is probably the *O. Carolinensis*, Conrad, a form very closely allied to *O. compressirostra*.

Ostrea divaricata, Lea. "Contributions to Geology," p. 90, pl. 3, fig. 69.
O. falciformis, Conrad.

This oyster is referred without doubt both by Nyst ("*Coquilles et Polypiers Fossiles*," 1843, p. 323) and Giebel (*Repertorium* to Goldfuss' "*Petrefacta Germaniæ*," 1866, p. 41) to the *O. flabellula* of Lamarck, which it certainly very closely resembles, and which is a very variable, and one of the most widely diffused forms of fossil oyster. It is cited by d'Orbigny (*Prodr. de Paléon.*) as occurring at Claiborne, Ala., and by Deshayes (*Animaux s. Vertèbr.*, *Bassin de Paris*) also at Cutch in India and Cairo in Egypt.

Pecten Deshayesii, Lea. "Contributions to Geology," p. 87.
P. Lyelli, Lea. "Contr. to Geol.," p. 88 (young).

Both of Lea's figured specimens are in the Academy's collection, and show beyond doubt that they belong to one and the same species, what there is of *P. Lyelli* corresponding precisely to the earlier formed portion of *P. Deshayesii*. This last must be carefully distinguished from the *P. Deshayesii* of Nyst ("*Coqu. et Polyp. Foss.*," p. 288), which was founded on the erroneous supposition that Lea's species was only a variety of *P. opercularis*, Lam.; a new specific name should therefore be given to the Belgian *Pecten*.

Cardita rotunda, Lea. Contr., p. 70, pl. 2, fig. 48, as *Venericardia*.

From a former comparison of this species with specimens of *Cardita imbricata*, Lam., from Grignon, France, it appeared to me as highly probable that the American form was at best but a variety of its European analogue, the main difference between the two being a tendency in the ribs of *C. imbricata* to become more crowded on the posterior slope (Proc. Ac. Nat. Sciences, 1879, p. 220). Nyst ("*Coquilles et Polypiers Fossiles*," p. 209) and Bronn ("*Index Palæontologicus*," i, p. 226) likewise refer, although with some doubt, the American species to the *C. imbricata* of Lamarck. A more favorable opportunity of comparison with numerous specimens from the Paris basin has convinced me, however, that although certain specimens from the American and French formations were but barely distinguishable from each other, there was, nevertheless, a certain constancy in the difference between the vast majority of the trans-Atlantic forms. The ribs of *C. imbricata*, besides, as above stated, being more crowded on the posterior slope, usually number 30–32, whereas in *C. rotunda* they rarely exceed 26. The anterior cardinal tooth in the left valve of the European form is considerably more oblique than in the American, and the inter-dental space correspondingly narrower. The lunule, which is deeply sunk, and scarcely visible in *C. imbricata*, is cordate, and prominently defined in *C rotunda*. *Cardita* (*Venericardia*) *squamosa*, Lam., with which species the comparison is made by Lea ("Contributions," Note, p. 207), besides differing in other respects, has only 18–20 ribs (Deshayes, "*Coquilles Fossiles, Environs de Paris*," i, p. 157.)

CARDITA PLANICOSTA, Lamk.

This species of *Cardita*, which is so extensively distributed over the Eocene deposits of Europe, is certainly identical with the similar forms of *Cardita* found in the same formation of the United States. Lea (Cont., p. 19) states that according to his observations the American species differs from the European in the number of its costæ (about 29 instead of 34), but on an examination of numerous French specimens I found the number to be frequently only 29. The distinctive character applied by Conrad to *Cardita dentata* (J. A. N. S., 2d ser., i, p. 130) of having crenulations on the umbones is possessed by many specimens of both the European and American *C. planicosta* that have come under my notice.

CARDIUM NICOLLETI, Conrad. J. A. N. S., viii, p. 190.

This *Cardium* is, I believe, identical with the *C. semigranulatum* of Sowerby (Mineral Conchology, ii, p. 99). It does not differ from a species of *Cardium* in the Academy Museum marked "*C. semistriatum*, London Clay," but as the *C. semistriatum*, Deshayes, differs, according to the description of its author, in the arrangement of its granulated striæ from the specimen in question marked *semistriatum*, and as the last agrees in characters with the description accorded by Sowerby to *C. semigranulatum*, it is highly probable that the names have been simply interchanged.

CORBIS (GAFRARIUM) LIRATA, Con. A. J. Science, i, 2d ser., p. 401.

This species was originally described by Conrad as the *C. lamellosa*, Lam., with the characters of which it was found to agree in all essential respects. I have been unable to note any material difference between the two species in question, and do not hesitate, after an examination of a number of specimens representing Lamarck's type, to unite the two under the one specific name of *lamellosa*.

ARCA ONOCHELA, Rogers (Latiarca).

Trans. Am. Phil. Soc., 1839, p. 372, as *Cucullæa*.
Latiarca idonea, Conr. Proc. A. N. S., 1872, p. 53 (no locality).

This species appears to be very closely related to, if not identical with, the *Cucullæa crassatina* of Lamarck, from the lower Soissonnais sands of the Paris basin, and, possibly, also from the British Bognor rock.

PECTUNCULUS.

After a careful examination of the figures and descriptions of the various species of *Pectunculus* found in the Eocene deposits of France, England, Belgium and Germany, I have found it impossible to determine with any amount of certainty whether the two most typical American species, *P. stamineus* and *P. idoneus*, are representative European forms, or whether they are to be regarded as distinct species. This difficulty in determination, which is partly due to the very great similarity existing between the numerous species, as well as to the inconstancy of character exhibited by them, has been greatly increased by a want of actual specimens for comparison, and by the very great confusion already existing in the scientific literature concerning this most difficult genus. *P. stamineus* appears to be distinct, but *P. idoneus*, at least in the younger forms, is but barely distinguishable from certain specimens in the Academy collection marked "*P. pulvinatus*, Lam., London Clay, Bracklesham, Sussex," differing only in being slightly less ventricose. The English specimens correspond to what has been separated by Searles Wood from *P. pulvinatus* as *P. proximus* ("Monograph of the Eocene Mollusca," Palæont. Soc. Rep., 1864, p. 99). The more ventricose specimens of *P. idoneus*, on the other hand, those which have the cardinal region comparatively more elevated, bear a most striking resemblance to *P. polymorphus*, Desh. (var. *microsomus*, "*Anim. s. Vertèbr.*, *Bassin de Paris*," p. 857), from which, in fact, if they differ at all, they appear to differ only in having the umbones further removed from each other.

LIMOPSIS AVICULOIDES, Conr. Foss. Shells of Tert. Form., p. 39, as *Pectunculus*.
Pectunculus obliquus, Lea.

This species, which has been allied by Bronn (*Index Palæontologicus*, ii, p. 936) with *Limopsis nana* of Deshayes, differs very materially from that species in the greater elevation of the umbones and cardinal region. From the *Trigonocœlia auritoides*, Galeotti, to which it is compared by Nyst (*Coqu. et Polyp. Foss.*, p. 243), it differs in its far greater obliquity, and in not having the external surface as regularly decussated as that species. It may at once be distinguished from the *Limopsis aurita* of Sassi (*Arca aurita*, Brocchi, *Conchiologia Fossile Subapennina*, ii, p. 485) by the crenulated margin. Its nearest representative appears to be the *Pectunculus* (*Limopsis*) *minutus*, Philippi (*Enumeratio Molluscorum Siciliæ*, p. 63), from the newest Tertiary deposits of Sicily, from which, in fact, it is but barely distinguishable by its greater obliquity, and in being slightly less ventricose. The Sicilian *Pectunculus minutus* (more properly *P. Reinwardtii*, Cantraine (*teste* Nyst, *Coqu. et Polyp. Foss.*; pp. 240, 244), must be carefully distinguished from the *P. minutus* of Goldfuss (*Petrefacta Germaniæ*, p. 163), described from Bünde, Westphalia, and Kleyn Spauwen, Belgium, and from the *P. minutus*, Philippi (*Beiträge zur Kentniss der Tertiærversteinerungen des Nordwestlichen Deutschlands*, 1843, p. 14, *non Enumeratio Mollusc. Siciliæ*), from the surroundings of Cassel. These two are the *Trigonocœlia Goldfussi* of Nyst (*Coqu. et Polyp. Foss.*, p. 243), an abundant Eocene (Oligocene?) species of Belgium.

LIMOPSIS ELLIPSIS, Lea. Contr., p. 78, pl. 3, fig. 56, as *Pectunculus*.

Whatever may be the value of the generic characters of *Stalagmium*, as established by Conrad, it appears to me as positive that the present species and *Stalagmium Nystii*, Galeotti (Nyst, *Coqu. et Polyp. Foss.*, p 238), belong to one and the same genus, for although in most of the specimens of the American species the posterior series of teeth does not exhibit that peculiarity to mount under the umbo and there break the continuity of the double series, as is pointed out by Nyst, other specimens, again, do manifest that tendency to a very marked degree. The similarity between the two species is, in fact, most striking, and at first sight one might be readily led to mistake the one for the other. Close comparison, however, shows that the umbones in the Belgium species to be considerably in advance of those of the American, and that whereas in *S. Nystii* the number of teeth in the anterior series is stated (Nyst) to be only 9, in the American species, on the other hand, it rarely falls below 12 (12–16 posterior).

TRIGONOCŒLIA CUNEUS, Conr. J. A. N. S., 2d ser., iv, p. 297, as *Limopsis*.
Nucula carinifera, Lea. Contr., p. 198.

This species so closely resembles, especially in the immature form, its European analogue, the *Nucula* (*Trigonocœlia*) *deltoidea*, Lam., that it becomes a matter of considerable difficulty to determine any positive characters by which to distinguish the two species The American species attains a considerably larger size than any English or French specimens of the *T. deltoidea* that have come under my notice, and the angle on the umbonal slope has less the aspect of a carination than in the European species (compared with specimens from the London Clay and the Paris basin). I have been unable to detect the differences stated to exist between the English and French forms of *T. deltoidea* (Searles Wood, "Monograph of the Eocene Mollusca," Palæontographical Society Reports, 1864, p. 106).

CORBULA ONISCUS, Conr. A. J. Science, xxiii, p. 341.
C. Murchisonii, Lea. Contr., p. 46.

This common American species is erroneously referred by Nyst (*Coqu. et Polyp. Foss.*, p. 65) to the *C. gibba*, Olivi, sp., instead of to *C. rugosa*, Lam., with the character of which last it appears to agree in all essential respects. We do not understand what is intended by the statement of Deshayes (*Encycl. Meth. Vers.*, ii, p. 10, *Coqu. Fossiles*, i, p. 51), that the *C. rugosa* never becomes rostrated posteriorly, when his figures (*Coqu. Foss.*, pl. 7, figs. 16, 17, 22) distinctly show it to be so. The American species, as in the case of the French, frequently resolves itself into two distinct layers, the inner of which may readily be mistaken for a new species (*C. bicostata?* Nyst).

CYTHEREA MORTONI, Conr. J. A. N. S., vii, p. 150.

This species, which was originally confounded by Conrad ("Fossil Shells of the Tertiary Formations," 1st ed., p. 34) with the *C. erycinoides*, Lam., and *C. suberycinoides*, Deshayes, differs from the former in being a considerably smaller shell, in having the ribs (50–60 in number) much more crowded and comparatively less robust, and in the sinual inflection, which is narrow and *parallel* sided, pointing obliquely upwards at an angle of about 45 degrees. In *C. erycinoides* the sinual angle is about

35 degrees, and the sinus broad and frequently expanding intermediably between the proximal and distal ends. (Compared with specimens from Bordeaux.) *C. suberycinoides*, Deshayes, which in form, size and the general disposition of the ribs, very closely resembles the American species, differs in the structure and arrangement of the cardinal teeth, the posterior tooth being bifid, and the anterior one diverging very broadly from the one in the centre, instead of more or less following the general curve of the latter (Deshayes, "*Coquilles Fossiles*," i, p. 129).

PSAMMOBIA EBOREA, Conr. Foss. Shells of Tert., 1st ed., p. 42.
Solecurtus Blainvillei, Lea. Contr., p. 49.

This species so closely approaches *Sanguinolaria compressa*, Sowerby (Mineral Conch., v, p. 91, pl. cccclxii), that the two may at first sight readily be mistaken the one for the other. Careful examination of the London Clay species, however, shows that the anterior of the two radiating lines on the external surface of the valves cuts the bases of those valves invariably at about their middle; whereas, in *P. eborea* the same line just as invariably cuts the base in about its last third. Were it not that I have found this character to be constant in all the specimens and figures of the two species I have been able to compare, I would not hesitate in considering the two as simple varieties of the same species.

Bronn's reference (*Index Palæont.*, ii, p. 1154) of Lea's *Solecurtus Blainvillei* to Sowerby's species is erroneous. Both Bronn (*loc. cit.*) and Nyst (*Coqu. et Polyp.*, p. 49) refer the *Sanguinolaria compressa* to the genus *Solecurtus*, a supposition probably partially based upon Sowerby's statement that the species belongs to the genus *Azor* of Leach. I cannot discover wherein it differs from *Psammobia*, and do not hesitate to place it with Charlesworth (MSS. Catalogue Charlesworth Collection, Ac. N. S.) in that genus.

TROCHITA TROCHIFORMIS, Lea. Contr., p. 96, pl. 3, fig. 76.

This species, described as new by Mr. Lea in 1833, is synonymous with *T.* (*Calyptræa*) *trochiformis* of Lamarck (*Trochus apertus*, Brand).

CYLICHNA GALBA, Conr. Foss. Shells of Tert., p. 34, as *Volvaria.*
(*Bulla St. Hillairii*, Lea.)

This species appears to me to be erroneously referred by Bronn to *Bulla constricta*, Sow. (Miner. Conch., vol. v, p. 96), as Sowerby's species has no fold on the columella —at least, no mention is made of it in his description, nor does it appear in his figure, or in specimens that I have examined coming from the London Clay.

TORNATELLA (ACTÆON) POMILIA, Conr. Foss. Shells of Tert., p. 45.
Actæon punctatus, Lea.
Monoptygma elegans, Lea.
= *Tornatella inflata?* Férussac.

TORNATELLA (TORNATELLÆA) BELLA, Conr. J. A. N. S., 2d ser., iv, p. 294.

On comparing *T. bella* with Sowerby's description and figures of *Auricula* (*Actæon*) *simulata* (*Bulla simulata*, Brander), as well as with a specimen of the London Clay fossil from Barton, England, I was unable to discover any appreciable difference between the two, and have accordingly united them into one species.

Brander's figure (*Fossilia Hantoniensia*, pl. iv, fig. 61), as pointed out by Sowerby (Mineral Conchology, ii, p. 144), has the spire more elevated than is actually shown by the specimens, a remark which is equally just when applied to a comparison with the American species.

SOLARIUM ORNATUM, Lea. Contr., p. 120.

This species is placed without doubt by Bronn (*Index Palæontologicus*, p. 1153) as synonymous with Lamarck's *S. canaliculatum* (*S. stramineum*). If the *Solarium* figured and described by Sowerby in the "Mineral Conchology" (vi, p. 43, pl. 524, fig 1), from Barton Cliff, be a true *S. canaliculatum*, then, in all probability, must the American *S. ornatum* be considered as forming a part of the same species, as I can find no characters by which to distinguish the two. Both appear to differ somewhat from the French form in the general disposition of the granulated striæ on the upper surface.

The *S. canaliculatum* was originally stated by Conrad (Foss. Shells of Tert., 2d ed., p. 34) to occur in the Alabama Eocene deposits, and the same was subsequently identified by Lycll (Jour. Geol. Soc. of London, i, p. 442) to be the equivalent form of the common species found at Claiborne.

NISO UMBILICATA, Lea. Contr., p. 103, as *Pasithea*.

In a former comparison made between this species and the *Bulimus* (*Niso*) *terebellatus* of Lamarck, I stated (Proc. A. N. S., 1879, p. 224) that I was "unable to detect the slightest difference between specimens obtained from both species." I had then overlooked the fact that the French specimens with which the comparison had been made, and which were originally considered by Deshayes as a mere variety of the well-known Paris species, had been subsequently separated by that author into a distinct species, *Niso angusta* ("*Anim. s. Vertèbr.*," *Bassin de Paris*, ii, p. 547, pl. 36, figs. 23, 24, 25). The American species should therefore equal *N. angusta*, and not *N. terebellata*.

PYRULA TRICOSTATA, Deshayes. *Coquilles Fossiles*, ii, p. 584, Atlas, pl. 79, figs. 10, 11.

Although I have no specimen of *Pyrula tricostata* for direct comparison, I have, nevertheless, but very little hesitation in referring the Alabama form, to which reference is made in the Proceedings of the Academy of Natural Sciences for 1880 (p. 374), to that species, as it agrees in all essential respects with the figures and descriptions as given by Deshayes in the *Coquilles Fossiles*. Three unnamed specimens of a *Pyrula* in the Academy collection from Dax, France, which I believe to be the *P. clava*

(Oligocene ?) of Basterot, somewhat resemble the Alabama species, but are comparatively much more robust, and have the costal nodes and revolving striæ considerably more developed.

PYRULA PENITA, Conr. Foss. Shells of Tert., p. 32.

P. tricarinata, Conr.
P. cancellata, Lea.
P. elegantissima, Lea.

This species is identical with *Pyrula nexilis*, Lam. (and var. *P. tricarinata* Lam.), which is a most variable fossil. Both American and European forms appear in the most diverse stages of convexity and angulation. Conrad, although he subsequently separated the trans-Atlantic forms into two distinct species, states (Foss. Shells of Tert., 2d ed., p. 39), "that the variety is not distinct I am assured by comparison of many specimens." What new determination, beyond the fact of geographical distribution, led to their subsequent separation by the same author, is unknown to me.

CYPRÆDIA FENESTRALIS, Conr. Proc. A. N. S., vii, p. 262.

It appears to me almost beyond doubt that this beautiful species is identical with the *Cypræa elegans* of Defrance (*Dictionnaire des Sciences Naturelles*, vol. 43, p. 39; Deshayes, *Coquilles Fossiles*, ii, p. 725, pl. 97, figs. 3, 4, 5, 6; Sowerby, Genera of Shells, fig. 7), with which, as far as I have been able to determine by comparison with the various figures and descriptions of that species, as well as with a single specimen from the Paris basin, it agrees in all essential characters. Conrad states that no mention is made by Deshayes of "microscopical regular lines" occurring in *C. elegans*, but an examination of the specimen in the Academy collection shows them to be present.

OLIVA BOMBYLIS, Conr. Foss. Shells of Tert., 2d ed., p. 42.
(*O. constricta*, Lea.)

Differs from the *O. mitreola*, Lam., in having the plications at base less numerous and somewhat less regular, and in wanting the upper of the two impressed revolving lines on the body-whorl. In the absence of the line it agrees more closely with *O. nitidula*, which was separated by Deshayes from the *O. mitreola* as a distinct species. The *O. clavula* of Lamarck appears to be very closely related to, if not identical with, the American species.

VOLUTA LIMOPSIS, Conr. J. A. N. S., 2d ser., iv, p. 292.

The *V. limopsis* corresponds so closely with the *V. crenulata*, Lam., that I feel very doubtful as to the propriety of considering it a distinct species. I know, in fact, of no positive characters by which to distinguish the two. The only departure from the description and figure of the French form as given by Deshayes (*Coquilles Fossiles*, ii, p. 693, Atlas, pl. 93, figs. 7, 8) that I can indicate, is the greater contraction anteriorly of the aperture. In this respect, however, it agrees with the form from the

London Clay (F. E. Edwards, "Monograph of the Eocene Mollusca," Palæont. Soc. Reports, 1852, p. 154, pl. xx, fig. 1, *a*, *b*), from which, again, it differs [agreeing with the Paris form] in the number (3) of the columellar folds.

CANCELLARIA TORTIPLICA, Conr. Am. Journ. of Conchol., vol. i, p. 211.

A comparison of this species with specimens of *C.* (*Buccinum*) *evulsa*, Brander (from Barton, England) shows the two to be most intimately allied to each other, the main difference being that in *C. tortiplica* the spire is somewhat more slender and elevated. As this may be only an accidental feature in the few examples which have come under my notice, I feel but little hesitation in uniting the two as one species. Bronn and Nyst (p. 477) refer with some doubt the *C. parva* of Lea to Brander's type, but this diminutive Alabama species has only two plaits on the columella instead of three, and is destitute of varices.

SIGARETUS CANALICULATUS, Sow. Min. Conch., iv, p. 115.

This shell is mentioned by Conrad (Foss. Shells of Tert., 2d ed., p. 34) as occurring at Claiborne, Ala. It is probably identical with *S. declivus* and *S. bilix*, Conr., which differ among themselves about as much as they do from the European species.

TURBINELLA (CARICELLA) BANDONI, Deshayes.

The large species of *Caricella* from Knight's Branch, Clarke Co., Ala. (Heilprin, Proc. A. N. S., 1880, p. 373), agrees so closely with the figures of *Voluta Bandoni*, Desh. (*Animaux sans Vertèbres, Bassin de Paris*, ii, pl. 102, figs. 13, 14), from the Paris basin, that I do not feel justified in considering it distinct. The American form appears to have been somewhat more elevated, but this is probably no more than a varietal circumstance.

FUSUS (BULBIFUSUS) INAURATUS, Conr. Foss. Shells of Tert., p. 29.

This *Fusus*, which is doubtfully referred by Bronn (*Index Palæontologicus*, i, p. 512) to the *F. ficulneus* of Lamarck, appears to hold an intermediate position between that species and *F. bulbiformis*, Lam. It agrees with *F. ficulneus* in the long and sharply reflected (sigmoid) apertural canal, but differs in the total absence of nodular ribs, even on the primitive whorls, those above the body-whorl being simply crenulated on their basal margins. The lengthy canal suffices to distinguish it from *F. bulbiformis*, with which, on the other hand, it agrees in the general absence of ornamentation on the whorls.

FUSUS (CLAVELLA) PACHYLEURUS, Conr. J. A. N. S., viii, p. 190.

This species closely resembles the *F. clavellatus* of Lamarck (*Annales du Museum*, ii, p. 317; Desh., *Anim. s. Vertèbr.*, 2d ed., ix, p. 481), and although the largest specimen in the Academy collection considerably exceeds in size the specimen of *F. clavellatus* figured in the *Encyclopédie* (pl. 425, figs. 1 *a*, *b*, 2 *a*, *b*), it may nevertheless, as in the case of that species, prove to be the undeveloped stage of a species which in the adult form more nearly resembles the well-known *F. longævus* of the European Eocene deposits.

FUSUS (STREPSIDURA) SUBSCALARINUS, Heilprin. Proc. A. N. S., 1880, p. 372.

This species greatly resembles the *Fusus scalarinus* of Deshayes (*Coquilles Fossiles*, ii, p. 574, pl. lxxiii, figs. 27, 28), but may be distinguished by the lesser prominence of its costæ, and by the presence of well-defined striæ over the entire surface of the whorls. In this last respect, as well as in the subangulated form of the whorls, it also differs from the *Fusus scalariformis*, Nyst (*Coquilles et Polypiers Fossiles*, p. 504, pl. xl, figs. 5 *a*, 6), from Lethen, Belgium.

PLEUROTOMA DENTICULA, Bast. Descrip. Géol. du Bass. Ter. Sud-ouest de la France, 1825, p. 63.

On a comparison of specimens of the *P. nodo-carinata*, Gabb (J. A. N. S., 2d series, vol. iv., p. 379), with the exhaustive analysis of the above species as given by Mr. F. E. Edwards in his "Monograph of the Eocene Mollusca" of England (Reports of the Palæontographical Society), I feel no hesitation in including it among the numerous varieties of Basterot's species. No mention is made by Gabb of a division of the central crenulation into a double series, but at least some of the specimens deposited in the Academy Museum, and marked with his specific name, show this feature distinctly. The *P. denticula* is a very widely distributed species of *Pleurotoma*, its range in Europe extending from England through Belgium (Nyst, "*Coqu. et Pol. Foss.*," p. 526) and France (Basterot, *sup.;* Grateloup "*Conchyl. Foss. des Terr. Ter.*," atlas, pl. 11 [20] fig. 8) to North Italy (Bellardi, "*Monog. Pleurot. Foss. del Piem.*," *Memorie della Reale Accademia di Torino*, 2d ser., vol. ix, p. 576). This species corresponds probably to some extent with Sowerby's *P. comma.* Unquestionable specimens of *P. denticula* from the Eocene of Alabama are to be found in the American Museum of Natural History of New York. Dr. Otto Meyer, who has recently made direct comparisons between the Claiborne form and specimens from the German Sternberger Oligocene, confirms my determination of identity (Proc. A. N. S., 1884, p. 107).

PLEUROTOMA ACUMINATA, Sowerby. Min. Conch., ii, p. 105.

In the Proceedings of the Academy of Natural Sciences of Philadelphia for 1880 (p. 374) I have indicated the probable presence of this species in the Eocene deposits of Clarke Co., Alabama.

MESOSTOMA RUGOSA, Heilprin. Proc. A. N. S., Oct., 1879.

This species might readily be mistaken for the *M. grata*, Desh. (*Anim. s. Vertèbr.* ii, p. 418), of the Paris basin, from which it differs only in the greater number of its revolving ridges.

CERITHIUM TRILINEATUM, Phil. *Enum. Mollusc. Sicil.*, i, p. 195.

Dr. Otto Meyer (Proc. A N. S., 1884, p. 105) recognizes this rather common European species in the *Terebra constricta* of H. C. Lea (Am. Journ. Science, xi, p. 100, pl. 1, fig. 18), described from the Eocene deposits of Claiborne, Ala. He also unites with it the recent *C. terebralis* of Adanson.

MELANIA CLAIBORNENSIS, Heilprin. Proc. A. N. S., Oct., 1879.

This diminutive *Melania*, which, to my knowledge, constitutes the only essentially fresh-water gasteropod found to the present time in the Claiborne marine formation, cannot in its characters be readily distinguished from the *M. mixta*, Desh., of the Paris basin (description and fig. in Deshayes, *Animaux s. Vert.*). Having observed but one specimen, and not wishing to definitely deduce its affinities from the characters drawn from a single example, I have provisionally applied to the American shell the specific name which it bears above.

OLIGOCENE.

OSTREA GEORGIANA, Conr. J. A. N. S., vii, p. 156.

I should not be surprised if on comparison with European specimens this species would be found to be only a variety of the *O. crassissima* of Lamarck, a common Miocene form. The resemblance to the figures of that species is very great, and if the American oyster does not assume quite the ponderous proportions of its European congener, the circumstance may be due to local causes, such as crowding. Conrad states that this species attains a length of 22 inches.

MIOCENE.

OSTREA VIRGINICA, Gmelin.
O. Virginiana, Lamarck.

A fossil oyster from the faluns of Touraine (also from the vicinity of Bordeaux) is recognized by Dujardin (*Mém. Soc. Géol. de France*, ii, p. 271) as being identical with the common form of our Atlantic coast.

ANOMIA EPHIPPIUM, Linn.

This recent species, which occurs in the Miocene deposits of North and South Carolina, is in some variety or other of its several forms found very abundantly in the Coralline Crag of Britain (Wood, "Crag Mollusca" [Palæont. Soc. Reports], ii, p. 8). It is also identified by Brocchi as belonging to the Pliocene (sub-Apennine) beds of Italy.

PERNA MAXILLATA, Lam.
Perna torta, Say.
Perna maxillata, Lam. Conrad, Foss. Med. Tert., p. 54, pl. xxvii.
(*V. ant.*, p. 78.)

I am satisfied of the thorough identity of the American and European form of *Perna* here referred to.

MYTILUS (MYOCONCHA) INCURVA, Conr. Foss. Med. Tert., p. 52, pl. xxviii, fig. 1.
(*V. ant.*, p. 78.)

NUCULA OBLIQUA, Say. Am. Journ. Science, ii, p. 46.

NUCULA PROXIMA, Say. J. A. N. S., ii, p. 270.

In the article "On the Relative Ages and Classification of the Post-Eocene Tertiary Deposits of the Atlantic Slope" I considered these two species as equivalents of each other. I am not positive whether this determination is a correct one, as unfortunately the want of illustrations to Say's descriptions renders a certain recognition of his forms, in the absence of type specimens, impossible. One form of *Nucula*, in all likelihood the *N. obliqua* of Say, occurs associated with *N. proxima* which is very much more oblique than that species, but not improbably it will prove to be only a variety passing into the other form by insensible gradations. Both Tryon ("American Marine Conchology," p. 180) and Gwyn Jeffreys ("Mollusca of Europe compared with those of Eastern North America," Ann. and Mag. Nat. Hist., Oct. 1872, p. 240) consider the *N. proxima*, also recent on the American coast, as distinct from the common *N. nucleus* of Europe (recent and fossil); for my own part I have not yet been able to determine any absolute characters by which to separate them, nor have I been able to detect the characters indicated by Say as possibly distinguishing the two. The decidedly oblique forms most resemble the *N. trigonula* of Wood, which not improbably is also referable to *N. nucleus* (*Vide* Wood, Supplement to "Crag Mollusca," p 113).

LUCINA CONTRACTA, Say. J. A. N. S., iv, p. 145.
L. filosa, Stimpson. Shells of New England, p. 17.

This species is identical with the *Lucina borealis* of Linnæus.

LUCINA CRENULATA, Conr. Foss. Med. Tert., p. 39.

This species is considered by Searles Wood ("Crag Mollusca," ii, p. 141) to be the probable equivalent of his own species of the same name, from the Coralline Crag of Sutton. Not having a specimen of the British fossil with which to make a comparison, I cannot pronounce upon this determination, but certainly the resemblance between the two forms is very striking.

LUCINA SQUAMOSA, Lamarck.
L. speciosa, Rogers. Trans. Am. Phil. Soc., new ser., v, p. 333.
L. squamosa, Lam. Conrad, Foss. Med. Tert., p. 38.

It appears to me a little doubtful whether the species described under this name as inhabiting our southern waters, and occurring in the Miocene deposits, is the true *squamosa* at all. At any rate, it differs essentially from the form, a fossil from the Paris basin, to which Lamarck first applied the name (Deshayes, *Coq. Foss. Env. de Paris*, i, p. 106), from which it can be readily distinguished by the smaller number and greater prominence of the ribs, as well as by their stronger ornamentation and dichotomization. The same features would seem to distinguish the American form from the *L. reticulata* (*L. pecten*), with which I had compared it on a previous occasion. [I am inclined to the opinion that the fossil described as *L. squamosa* from the Paris and Mentz basins will prove to be identical with the later *L. reticulata* from the deposits about Vienna, etc., despite the characters which Sandberger (*Conch. Mainz. Tertiaerbeckens*, p. 330) claims to be present as distinguishing the two.]

LUCINA DIVARICATA, Linn.

I am confident that the species described under this name as occurring fossil in our Miocene deposits, and which is still living along the southern coast, is identical with the well-known *L. ornata*, Agassiz (*Icon. Coq. Tert.*, *Nouv. Mém. Soc. Helv.*, vii, p. 64; *Lucina divaricata* of Lamarck, in part), of Europe. Its reference to *L. dentata* of Wood, which is concurred in by many conchologists, appears to me erroneous, as the primary character—the serration of the circumferential margin and of the concentric striæ—claimed by Wood ("General Conchology," i, p. 194, pl. 46, fig. 7) to separate his species from the *L.* (*Tellina*) *divaricata* of Linnæus, is wanting.

LUCINA ANODONTA, Say. J. A. N. S., iv, p. 146.

This species, if not identical with, is certainly the immediate representative of, the form described by Hörnes (*Die Fossilen Mollusken des Tertiaerbeckens von Wien*, ii, p. 228) from the Vienna basin as *Lucina Miocenica* (Michelotti). The only distinguishing character between the two appears to be the absence in the American form of the two radiating sulci which mark the external surface of the European shell. No mention of this character, however, is made by the author of the species, Michelotti (*Brevi Cenni di alcuni Resti delle Classi Brachiopodi*, p. 24; *Descrip. Foss. Terr. Mioc.*, p. 114, pl. 4, fig. 3), and, possibly, it may not be a permanent one. It appears not unlikely, on the other hand, that Hörnes' identification of the Vienna form with that from the deposits about Turin is erroneous, for, apart from the distinguishing character just referred to, the true or Italian *L. Miocenica* has well-developed hinge teeth, whereas in the (supposed) same species from the Vienna basin, as also in the American *L. anodonta*, the hinge-teeth are only exceedingly rudimentary, or completely absent.

ASTARTE BELLA, Conr. Proc. A. N. S., 1862, p. 585.

This species differs from the *A. gracilis* of Münster (Goldfuss, *Petrefacta Germaniæ*, ii, p. 194, pl. 135, fig. 4 *a–c*), a fossil from Bünde, and from the Coralline and Red Crags of Sutton, etc., in its greater size, more triangular form (the posterior slope being reflected outwards), and in the general flatness of the valves (compared with specimens from Oxford, Suffolk.) The *A. lirata*, Conr., referred to by Lyell (Q. J. Geol. Soc., 1845, p. 421) as a fossil from the American Miocenes, and compared with the *A. gracilis*, is doubtless the much later described *A. bella* (also *A. compsonema*).

ASTARTE UNDULATA, Say. J. A. N. S., iv, p. 150, pl. 9, fig. 5.

This very variable and common form of *Astarte* may be regarded as the American representative of the *A. Omalii*, which it very closely resembles, and with which it has sometimes been identified by geologists. (See Lyell, Q. J. Geol. Soc., 1845, p. 421; Searles Wood, "Crag Mollusca," ii, p. 180.) The form of *A. Omalii* to which it appears to be most nearly related is the *A. bipartita* of Sowerby (Min. Conch., pl. 521, fig. 3), but it can be readily distinguished from this by the comparative narrowness of the interdental pit, the greater length of the teeth, their more prominent lateral striation, and in the posterior angulation of the shell, which consequently appears trigonal instead of rounded.

ERYCINELLA OVALIS, Conr. Foss. Med. Tert., p. 74, pl. 42, fig. 5.
Goodallia ? pygmæa, S. Wood. Catalogue, 1840.

Found in the Coralline Crag of Sutton and Gedgrave. By actual comparison with the English species I have satisfied myself of the correctness of Conrad's determination, as recorded in a letter to Sir Charles Lyell (Wood, "Crag Mollusca," ii, p. 172, foot-note).

ISOCARDIA MARKOEI, Conr. Bull. Nat. Inst., i, p. 193, pl. ii, fig. 1.
(*V. ant.*, p. 78.) (Isocardia fraterna.)
ISOCARDIA FRATERNA, Say. J. A. N. S., iv, p. 143, pl. xi, fig. 1, *a*, *b*.
Isocardia rustica, Conr. (*non* Sowerby.) Foss. Med. Tert., p. 20, pl. xi, fig. 1.
(*V. ant.*, p. 78.)

This species differs from the typical *Isocardia cor* (recent and fossil), with which it has been united by Deshayes, Hörnes, Giebel, and Wood, in the general form of the shell, which is more elongate or transverse (less orbicular), in the posterior angulation of the basal margin, in the lesser prominence of the umbones, and in the more pronounced carination of the posterior slope. Yet the general aspect is very much that of the European form, and despite the differences that have here been pointed out, it may prove to be no more than a geographical variety of that species.

CHAMA CORTICOSA, Conr. A. J. Science, xxiii, p. 341.

Differs from the *Chama gryphina* of Lamarck, which it otherwise very closely resembles, in the absence of the prominent umbonal sulcus on the outer surface of the larger valve. May possibly prove to be only a variety.

ARTEMIS ACETABULUM, Conr. Foss. Shells Tert. Form., p. 20, pl. vi, fig. 1.
(*V. ant.*, p. 73.)
ARTEMIS INTERMEDIA, Conr. Proc. A. N. S., 1862, p. 575.
Venus concentrica, Tuomey and Holmes. Plioc. Foss., p. 82.

This species, not unlikely only a variety of *A. acetabulum*, differs from *A. lentiformis* (Sowerby) of the English Crag, which it most closely resembles, in the absence of the posterior angulation immediately back of the ligamental area.

MACTRA CONGESTA, Conr. A. J. Science, xxiii, p. 340.

This form, which in a measure recalls the *M. ovalis*, Sow., of the British Crag deposits (with which it is compared by Wood, *op. cit.*, ii, p. 246), may be distinguished from that species by its relatively thicker shell and greater lateral extension. The same characters, in addition to the absence of transverse striations on the lateral teeth, likewise distinguish the *M. fragosa* (*M confraga*).

PANDORA TRILINEATA, Say. J. A. N. S., ii, p. 261.
Pandora crassidens, Conr. Foss. Med. Tert., p. 2.
Pandora inæquivalvis, Linn.

A rather rare fossil from the newer Tertiary deposits of the Vienna basin, Britain, Switzerland, and Sicily.

SAXICAVA BILINEATA, Conr. Foss. Med. Tert., p. 18.
Saxicava distorta, Say. J. A. N. S., ii, p. 318.
Saxicava arctica, Linn. (*et S. rugosa*).

A fossil of the Vienna basin, the British and Antwerp Crag, and the newer Tertiary and post-Tertiary deposits of Italy and Scandinavia.

PANOPÆA AMERICANA, Conr. Foss. Med. Tert., p. 4, pl. ii.
(*V. ant.*, p. 52.)
PANOPÆA PORRECTA, Conr. Foss. Med. Tert., p. 71, pl. 41, fig. 2.

This species severely recalls the *P. gentilis* of Sowerby (Min. Conch., vii, pl. 610, fig. 1), from the Red Crag of England, considered by Wood ("Crag Mollusca," ii, p. 283, pl. xxvii, fig. 1 *a–e*), and Mayer (*Cat. Foss. Terr. Tert.*, 1870) to be only a variety of the large fossil found so extensively distributed throughout the newer Tertiary deposits of Europe, the *P. Menardi* (*P. Faujassii* of Wood, *non* Menard). Its elongated form would seem to indicate a species distinct from the last.

SOLEN ENSIS, Linn.
Solen ensiformis, Conr. Foss. Med. Tert., p. 76, pl. 43, fig. 8.

A fossil of France, Belgium, Germany, Italy, and England. Hörnes (*Foss. Moll. Tertiaerb. Wien*, ii, p. 15) separates the Belgian and British form, as well as the closely related one from Grund, Austria, as a distinct species (*Ensis Rollei*), from the circumstance of the anterior extremity being more rounded than is commonly the case with the recent species. It appears to me very doubtful, however, whether this character will be found sufficient to distinguish the two.

MUREX UMBRIFER, Conr. Foss. Shells Tert. Form., p. 17, pl. 3, fig. 1.

Represented by *M. Delbosianus*, Grateloup (*Conchyl. Foss.*, *Bassin de l'Adour*, pl. 30, figs. 7–10; *non* Hörnes, *Foss. Moll. Tertiaerb. Wien*, i, p. 675, pl. 51, fig. 7 *a*, *b*), a fossil of the faluns of Bordeaux and Dax. The varices in the American form are more numerous, and more lamellar in character.

FUSUS ROSTRATUS, Dujardin (Olivi?). Mém. Soc. Géol. de France, ii, p. 293.

Lyell identifies this Touraine fossil as having been found at Burwell's Mill, Williamsburg, Va. (Q. J. Geol. Soc., i, p. 420).

ECPHORA QUADRICOSTATA, Say. J. A. N. S., iv, p. 127.

Represented in the deposits of the faluns of Bordeaux and Dax by *Pyrula Jauberti*, Grateloup (*op. cit.*, pl. 27, figs 11, 12), from which it differs in the number (four, instead of three) and greater prominence of the revolving ridges, in the greater size of the umbilicus, and in the reflected position of the apertural canal.

PURPURA LAPILLUS, Linn.

Lyell identifies a form from Petersburg, Va., as a variety of this species, one of the most abundant fossils of the Red Crag, and considers it to be the equivalent of the *P. crispata*, Wood (Q. J. Geol. Soc., i, p. 420; Wood, "Crag Mollusca," i, pp. 36–38).

PTYCHOSALPINX (BUCCINUM) ALTILIS, Conr. Foss. Shells Tert. Form., p. 19, pl. 4, fig. 6.
(*Et al. sp. Ptychosalpinx?*)

Represented in the British Crag by forms of *Nassa reticosa*, Sow. (Wood, "Crag Mollusca," i, p. 33, pl. iii, figs. 10 *a–h*.)

PARANASSA (BUCCINUM) HARPULOIDES, Conr. Proc. A. N. S., i, p. 326.

Differs from *Buccinum contortum* of Dujardin (*Mém. Soc. Géol. de France*, ii, p. 298, pl. 20, figs. 1 and 2) in the thickened outer lip, and its interior rugation.

OLIVA LITTERATA, Lam.
O. Carolinensis, Conr. Proc. A. N. S., 1862, p. 584.

Hörnes (*op. cit.*, i, p. 50), incorrectly, I believe, identifies this well-known American species with the *O. clavula* of Lamarck, from which it differs in the general form of the shell, and in the characteristic rugation of the entire columellar surface. The Vienna fossil referred to *O. clavula* is probably also a distinct species, agreeing in form more with the American, but differing likewise in the absence (?) of the columellar rugations, and in the presence of a second baso-dorsal band, which is wanting in *O. litterata*.

VOLUTIFUSUS (FASCIOLARIA) MUTABILIS, Conr. J. A. N. S., vii, p. 135.

This species, although generally recalling in habit the well-known *Voluta Lamberti* of Sowerby, of which it may be considered the American representative, differs from that species in several particulars and more particularly in the number (two, instead of four) and disposition of the columellar folds.

CYPRÆA CAROLINENSIS, Conr. A. J. Science, xli, p. 346, pl. ii, fig. 6.

This species appears to be identical with the *C. globosa* of Dujardin (*loc. cit.*, p. 303, pl. xix, fig. 21), a fossil from the faluns of Touraine, the Vienna basin, etc.

Natica heros, Say. J. A. N. S., ii, p. 248.

I have been unable to discover any character by which to separate the *N. catenoides* of S. Wood from this species.

Turritella plebeia, Say. J. A. N. S., iv, p. 125.

Identified by Lyell and G. B. Sowerby (Q. J. Geol. Soc., i, p. 420) with a form very abundant in the faluns of Touraine, and which Dujardin has referred to the *T. Linnæi* of Deshayes (*T. communis?* Risso).

Crepidula unguiformis, Lamarck.
C. plana, Say. J. A. N. S., ii, p. 226.

A fossil from the Miocene deposits of France, Italy, Austria, etc.

Dentalium attenuatum, Say. J. A. N. S., iv, p. 154.
= *Dentalium dentale*, Linn.

Identified by Lyell and G. B. Sowerby (Q. J. Geol. Soc., i, p. 421) with the *D. costatum* of J. Sowerby, a common fossil of the Red and Coralline Crag.

Doubtless, many other species besides those here enumerated will be found to agree very closely, if not absolutely, in their characters with common European forms, but for their proper determination more material is necessary than is at the present time at the disposition of the author.

VI.

ON THE AGE OF THE TEJON ROCKS OF CALIFORNIA, AND THE OCCURRENCE OF AMMONITIC REMAINS IN TERTIARY DEPOSITS.

The controversy which for a long time was maintained between Conrad and Gabb as to the age of the Tejon rocks of California, referred by the former to the Eocene series, and by the latter considered to represent the uppermost member of the Cretaceous (Division B of the California Report), can scarcely be considered to have settled the question at issue.* Both paleontologists appear to have maintained their respective positions to the last, and to have permitted no considerations to outweigh the mass of proof that at the same time was bearing in both directions.† The essence of Conrad's views briefly stated is: That a portion of the rocks, that of Cañada de las Uvas, included in the Cretaceous, fails "to show one Cretaceous fossil," whereas, on the contrary, it is held to contain at least two representative, and at the same time highly characteristic Tertiary forms—"*Venericardia planicosta* and *Aturia zic-zac*;" and that where in other deposits referred to the same horizon, an association between Tertiary and Cretaceous species obtains, such an association has been brought about as the result of the breaking up of the materials of an older formation, and the mixing up, of their contained remains with those of a newer period. By Gabb, on the other hand, it is maintained that many of the forms referred to as Tertiary species are in reality not such; that a repeated admixture between what have been considered to be strictly Tertiary forms and Cretaceous species manifests itself throughout the entire Californian (so-called) Cretaceous series; and that no such breaking up and re-formation, as has been claimed by Conrad, are anywhere apparent.

The most elaborate defense of Gabb's position is that published in the "Proceedings" of the California Academy of Natural Sciences for 1867 (pp. 301–6), in a paper entitled "On the Subdivisions of the Cretaceous Formation in California." In this paper the author essays to show, by means of comparative tables, the close relation that exists between the faunal characters of the upper and lower members of his Cretaceous group (Divisions B and A of the California Report), and to prove by this relationship the fallaciousness of a classification that would relegate the deposits of the group to two distinct eras in geological chronology. The following table of organic remains representing the fauna of the Tejon group (Division B), with the various localities of their occurrence, is there appended:*

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* Conrad, Amer. Journ. of Conchology, i (1865), pp. 362–5; ii (1866), pp. 97–100; Amer. Journ. of Science, new ser., xliv, (1867), pp. 376–7.

Gabb, Amer. Journ. of Conchology, ii (1866), pp. 87–92; Amer. Journ. of Science, new ser., xliv (1867), pp. 226–9; Proc. California Acad. Nat. Sciences, iii (1867), pp. 301–6.

† The writer is informed by one who is intimately acquainted with both parties, that Conrad finally yielded his position, but he has been unable to discover the evidences of such a change of opinion in any of that author's writings.

	Upper Division (B.)	Intermediate Beds.	Lower Divisions and Remarks.
Calianassa Stimpsonii,	C. T.		Chico.
Aturia Mathewsonii,	M. C. T.		Martiñez.
Nautilus Texanus,	C.		Shasta Co.
Ammonites, n. s.,	C. M.		Curry's; Benecia; Martiñez.
Typhis antiquus,	M. T.		
Fusus Martiñez,	M. T.		
F. Mathewsonii,	M. C.		Curry's.
F. Diaboli,	C.		
F. aratus,	M.		
F. Californicus,	C. T.	LL.	
Hemifusus Hornii,	T.		
H. Cooperii,	C. D.		
H. Remondii,	M. C. T. G.		
? Neptunea supraplicata,	C. D.		
N. gracilis,	M.		
Perissolax brevirostris,		LL.	Many localities.
P. Blakei,	M. C. T.		
Turris Claytonensis,	C. T.		
T. raricostata,	C.		(*Varicostata* by error in Rep.)
Cordiera microptygma,	T.		
Tritonium Hornii,	C. T.		
T. Diegoensis,	D.		
T. paucivaricatum.	T.		
T. Whitneyi,	T. D.		
Buccinum liratum,	M.	LL.	
Nassa cretacea,	M. T. G.		
Pseudoliva lineata,	M.		
P. volutæformis,	T.		
Olivella Mathewsonii,	M. T. G. C.		
Ancillaria elongata,	C. D.		
Fasciolaria læviuscula,	C.	LL.	
F. sinuata,	T. D.		
F. Io,	T.		
Mitra cretacea,	M.		

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* A few species occurring in beds said to be intermediate between B and A, but not properly belonging to the Tejon Group, are here included. In addition to the 107 (112, inclusive of those from the "intermediate" beds) species enumerated in the list, a small number of other forms have been described in vol. ii (1869) of the "Palæontology" of the California Survey. The different localities in the above tables are designated by letters, as follows: M, Martiñez; C, Clayton to Marsh's; T, vicinity of Fort Tejon; G, a locality 10 miles west of Griswold's, near New Idria; I, New Idria; D, San Diego; LL, Lower Lake Village, 1 mile southeast of the town.

	Upper Division (B.)	Intermediate Beds.	Lower Divisions and Remarks.
Whitneya ficus,	T.		
Ficus mamillatus,	T.		
Natica Uvasana,	T.		
Lunatia Shumardiana,		LL.	Martiñez and elsewhere.
L. Hornii,	T.		
L. nuciformis,	C. T. (D.?)		
Gyrodes expansa,		LL.	Almost everywhere.
Neverita secta,	T.		
N., n. s.,	G. I.		
Naticina obliqua,	M. T.		
Amauropsis alveata,	M. C. T. G. D.	LL.	Curry's; S. of Mt. Diablo.
Morio tuberculatus,	M. T. C. G. D.		
Scalaria (Opalia) Mathewsonii,	M.		
Niso polita,	M. T.		
Cerithiopsis alternata,	M. C.		
Architectonica cognata,	M. C. T.		
A. Hornii,	T.		
Margaritella crenulata,	D.		
Conus Remondii,	M. C. T. D.		
C. Hornii,	T.		
C. sinuatus,	T.		
Rimella canalifera,	M. T.		
R. simplex,	C. D.		
Aporrhais angulata,	M.		
Cypræa Bayerquei,	M. C.		
Turritella Uvasana,	M. C. T. G.		
T. Saffordii,		LL.	M. and Solano Co.
T. infragranulata,	M.		
Galerus excentricus,	M. C. T. D. I.	LL.	
Spirocrypta pileum,	T. I.	LL.	
Gadus pusillus,	M. T.		
Dentalium Cooperii,	M. D.		Curry's; S. of Mt. Diablo.
D. stramineum,	M. D.		Curry's; S. of Mt. Diablo.
Bulla Hornii,	T.		
Cylichna costata,	M. C. T. D.		M.; Texas Flat and many [other localities.
Megistostoma striata,	M.		
Martesia clausa,	G.		Pence's; Texas Flat, etc.
Solen parallelus,	M. C. T.		
Solena Diegoensis,	D.		
Corbula Hornii,	T.		
C. parilis,	G. M. D.		
Neæra dolabræformis,	M.		
Mactra Ashburnerii,	M. C. T.		Nearly everywhere in [both Divisions.
Gari texta,	M.		
Tellina longa,	M. C. T.		
T. Remondii,	C. T.		

	Upper Division (B.)	Intermediate Beds.	Lower Divisions and Remarks.
T. Hoffmaniana,	G.		M.; Pence's, and elsewhere.
T. Hornii,	T.		
T. Californica,	C. T.		
Meretrix Uvasana,	M. C. T. I. G. D.		
M. Hornii,	T.		
M. ovalis,	T.		
Dosinia elevata,	T.		
D. gyrata,	M. C. T. G.		
Tapes Conradiana,	G. M. T.	LL.	
T. quadrata,	M. T.		
Cardium Cooperii,	M. T. D.		
C. Brewerii,	M. C. T. G.		
Cardita Hornii,	M. C. T. I. G.		
Lucina cumulata,	T.		
L. cretacea,	C.		
Mysia polita,	M. C. I.		
Crassatella grandis,	M. T.	LL.	
C. Uvasana,	T.		
Mytilus ascia,	T.		
Modiola ornata,	M. C. T. I.		
Septifer dichotomus,	T.		
Crenella concentrica,	M.		
Avicula pellucida,	M. G.	LL.	San Luis Gonzaga.
Arca Hornii,	T.		
Cucullæa Mathewsonii,	C.	LL.	M.
Barbatia Morsei,	D.		
Axinæa sagittata,	M. T. G.		
A. Veatchii,		LL.	M.; Tuscan Springs, etc.
Nucula (Acila) truncata,	M. T.		Everywhere.
Leda protexta,	M. C. T. G.		M.
Placunanomia inornata,	D.		
Flabellum Remondianum,	C.		

Of the total number of 112 species here enumerated, 105 are recorded as being found in Division B (Tejon group), 15 in the so-called "intermediate beds," and 21 in various deposits of the lower group (Division A). The number of forms held in common by Divisions A and B, as is shown by the above table, and the intimate faunal relations which the "intermediate beds" hold to the deposits supposed to lie above and below them, it is claimed, demonstrate conclusively that the series is a continuous one, and admits of no such separation as has been insisted upon by Conrad.

The value of a comparative table, such as is here presented, naturally depends upon the accuracy of its details; whether in the present instance this accuracy is such as to entitle the table to special consideration, remains to be seen. On page 302 of the paper last referred to, Mr. Gabb states: "Of 280 species of fossils recognized and named in the California Cretaceous rocks, 107 are found in this upper member. Of these, 84 are peculiar, *and 23 are found in common between undoubted members of this group and undoubted members of the older group.*" The inaccuracy of this last assertion will be readily manifest when an appeal is made to the data afforded by the preceding table.* It will be seen that here only 16 species are enumerated whose range comprises the "undoubted members" of both the older and newer groups (A and B), as follows:—

Callianassa Stimpsonii,
Aturia Mathewsonii.
Nautilus Texanus,
Ammonites, n. s.,
Fusus Mathewsonii,
Amauropsis alveata,
Dentalium Cooperii,
D. stramineum,
Cylichna costata,
Martesia clausa,
Mactra Ashburnerii,
Tellina Hoffmanniana,
Avicula pellucida,
Cucullæa Mathewsonii,
Nucula (Acila) truncata,
Leda protexta.

But in glancing over the original descriptions of the species here cited, as given in vol. i of the Palæontological Report, and the more recent list of distribution published in vol. ii, we find—

1. Vol. i, p. 59, that all the specimens (4) of *Nautilus Texanus* were obtained from Division A (older group), no reference being there made of its occurrence in any deposit of newer date; nor is any mention of the species being found in Division B made in the more recent list of distribution (p. 209) contained in vol. ii of the Report (1869). In vol. ii of the "American Journal of Conchology" (p. 88) the species is quoted from Clayton (B), but Mr. Gabb has here evidently confounded the name of a finder ("the last was found by Mr. Clayton") with that of the locality.

2. Vol. i, p. 195, no indication is given of the occurrence of *Cucullæa Mathewsonii* in deposits belonging to Division B, although the locality Martiñez, where beds representing both B and A are to be met with, is given. From this indefinite statement it might he inferred that the specimens were obtained from the upper beds, but any doubt on this point is set at rest by the subsequent reference (Amer. Journ. Conchol. ii, p. 88; Cal. Pal. Rept., ii, p. 249), of these Martiñez beds to the Martiñez group (A). The second locality given (for a single specimen) is "Clayton, *below* † the coal-veins," which in vol. ii, of the report (*loc. cit*) is referred to the "intermediate beds."

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* Mr. Gabb has here evidently included the "intermediate beds" among the "undoubted members of the older group," and yet to disclaim any intention on his part for so doing, he adds (immediately following the sentence above quoted): "Besides this, I was fortunate enough to discover a locality near Clear Lake, this fall, where, within a space of two feet, I found an admixture of upper and lower forms, proving the existence of a transitionary bed, or, perhaps, group of beds." In justice to Mr. Gabb, it must be stated, that on p. 305 of the same paper, only 16 species, a figure more nearly the correct one, are stated to be common to Divisions A and B.

† The italics appearing in the quotations belong to the writer of this article.

So that deducting these two forms which have not yet been detected in the deposits of Division B, these last have at the utmost (at least as far as is known), only 14 species common to the lower division (A), instead of 23 as claimed.

But while 14 species *may* actually be held in common by the upper and lower members, we are far from satisfied that such really *is* the case. Thus, Mr. Gabb states (Pal. Report, i, p. 153), that *Mactra Ashburnerii* "is one of the most common fossils in the State," and instances numerous localities of its occurrence in both Divisions A and B; and further (in Am. J. Conchol., ii, p. 88), that it is found in "almost every locality of both divisions." It would certainly be a difficult matter to disprove such an affirmation, but it is, to say the least, surprising, that after a careful examination of all the specimens of the Gabb collection in the possession of the Academy of Natural Sciences, which have served as the basis of the Palæontological Report, and which comprise probably the greater number, if not nearly all, of the Cretaceous "types" and figured specimens, we have failed to discover a single fragment from Division A (Martiñez, Chico, and Shasta groups) that could with any amount of positiveness, or with anything more than considerable doubt, be referred to the form that under the same name is credited to Division B (Tejon group). This is the more singular since the collection embraces a very considerable number of rock fragments, which are crowded with molluscan remains. Two specimens marked in Gabb's handwriting as coming from Texas Flat (Chico group, A), and considered by that paleontologist to represent the "typical form" (so marked) of the species, differ very essentially in outline from the Tejon specimens, and are doubtless specifically distinct. Again, in the case of *Nucula truncata* Mr. Gabb instances (Pal. Rept., i, p. 199) several localities of its occurrence in Division A, and also Martiñez as a locality of Division B, but no mention is made of the last named as a locality of the first Division. On the other hand, *all the Martiñez specimens of this species in the Gabb collection are marked as belonging to Division A!* In vol. ii (p. 197) of the Reports, however, we are informed that this species is "found at almost every locality of the Chico, Martiñez, and Tejon groups," but we must confess that, after a diligent search, we have failed to discover among the Tejon rock fragments anything that could with sufficient evidence be referred to this form. Nor have we been able to find the faintest traces of *Leda Gabbii* (*protexta* of Gabb) (or for that matter, of several other forms belonging to group B) in the rock fragments obtained from the older members, but it would perhaps be premature to conclude from this that it may not really occur there. On page 199 of vol. i, the only locality given for Division A is (near) Martiñez (at the same time a locality for Division B), but in the "tabular statement" appended to the same volume (p. 235) the ranch of San Luis Gonzaga is substituted instead. *Tellina Hoffmanniana* is not stated in the original description (vol. i, p. 156), to be found in any locality of Division B, nor is it included in the list of "common" species given in 1866 in the American Journal of Conchology (ii, p. 88). In vol. ii of the Reports, however (p. 182), this species, which could originally "always be distinguished by its straight or slightly convex cardinal margins," but which has now become a "rather variable" form, is reported from two localities (Martiñez and "Griswold's") of the Tejon group. An inspection of Mr. Gabb's figures (i, pl. 22, figs. 33–33 *a*; ii, pl. 30, fig. 72) will, we believe, fail to convince one that in both instances the same species is represented, and, indeed, in the Martiñez (B) specimens the "straight or slightly convex cardinal margins" characteristic of the species have become both anteriorly and posteriorly *decidedly* convex.

Mr. Gabb invokes the assistance of his "intermediate beds," unknown to him at the time of the publication of the first volume of his Reports, to prove the intimate relation that exists between the upper and lower members of his Cretaceous series. An examination of the preceding table will show that 7 species, not found in deposits older than the intermediate beds, are credited as being common to these last and the Tejon group, as follows;—

Fusus Californicus,
Buccinum liratum.
Fasciolaria læviuscula,
Galerus excentricus,
Spirocrypta pileum,
Tapes Conradiana,
Crassatella grandis.

These are said to be associated with a limited number of forms that are found in the lower division, but which do not pass above, and (if we except *Cucullœa Mathewsonii*, which has been shown *not* to belong to the upper member) with only one *solitary* form, *Avicula pellucida*, that is common to both divisions, a circumstance of suspicious import. But in turning to the original description of *Fasciolaria læviuscula* (vol. i, p. 101) we find no mention of its being found in deposits belonging to Division B, but on the contrary, it is distinctly stated to have been "found in the strata immediately *below* the coal in the Mount Diablo district" (although it was *associated* with several species found also at San Diego and Martiñez of Division B), and in vol. ii of the Report (p 223), *only* the "beds intermediate between the Martiñez and Tejon groups" are given as the locality of its occurrence. Nor do we find in the lists of distribution contained in vol. ii* any mention of the "intermediate beds" in the case either of *Buccinum* (*Brachysphingus*) *liratum*, *Galerus excentricus*, or *Spirocrypta pileum*, although it does occur in the case of the remaining three (*Fusus Californicus*, *Tapes Conradiana*, and *Crassatella grandis*).

We believe it may be fairly questioned, from what has already been shown, whether Mr. Gabb's tables afford *at all* a safe criterion upon which to base the solution of the problem at issue. The numerous discrepancies would seem to prove almost conclusively that in their preparation the author was in a measure, or even to considerable part, borrowing from his memory, or, at any rate, not absolutely from the data that were presented in the field. But granting that the tables be entirely trustworthy in the statements that have been called into account, do they at all prove his case? We believe most assuredly not. Surely a geologist would find it difficult, on the assumption of immediate continuity and without the assistance of a change in the general character (whether marine, fluviatile, or terrestrial) of the fauna, to account for the rather anomalous circumstance, that, in a locality rich in organic remains, the upper member of a closely connected series should be characterized by a fauna about 80 per cent.* of whose individual forms is peculiar to itself. In order to antagonize this difficulty, and, at the same time, to show still more effectively how much more closely the members of this upper group of deposits are linked to the beds below them (and, consequently, how indisputably Cretaceous) than to those following (and, therefore, how little Tertiary), Mr. Gabb submits the argument (Proc. Cal. Acad. Nat. Sciences, 1867, p. 306; A. J. Science, new ser., vol. xliv, p. 229), that "All of the species are peculiar to this group (B), or to this and *underlying*† rocks; *not one* has been found associated either with living forms, or with species known to occur in the recognized Tertiaries of California. Five of the genera are peculiar to the Secondary. An Ammonite ranges entirely through the group to the top of the highest fossiliferous strata. The genera *Perissolax*, *Gyrodes*, *Margaritella*, and the subgenus *Anchura*, of the genus *Aporrhais*, are all recognized as strictly characteristic of the Cretaceous; so much so, that the presence of a single undoubted representative of either of these genera would be strong presumptive evidence of the Cretaceous age of any rocks in which it might be found." But Mr. Gabb omits to emphasize in this connection (although a casual reference to a part of the facts is made), and as directly bearing upon the subject of chronological relationship, the *first* appearance (in California) in the deposits of this group of the genera (among others) *Ancillaria*, *Bulla*, *Conus*, *Cypræa*, *Crepidula* (*Spirocrypta*), *Cassidaria* (*Morio*), *Ficus*, *Gadus*, *Mitra*, *Nassa*, *Niso*, *Olivella* (or *Oliva*), *Pseudoliva*, *Rimella*, *Triton*, *Trochita*, and *Typhis*, many of them distinctively, and as has been generally recognized, *exclusively* Tertiary forms. Nor does that paleontologist appear to lay the least stress upon, or even advert to, the circumstance that the eminently Mesozoic genera *Ancyloceras*, *Hamites*, *Helicoceras*, *Turrilites*, *Crioceras*, *? Ptychoceras* (*Helicancylus*), *Baculites*, *Inoceramus*, *Trigonia*, *Gryphæa*, and *Exogyra*, which are found in one or other, or several of the deposits of the older group (A), are here completely wanting. Surely the wholesale appearance and disappearance of characteristic genera have *at least* as much import in the determination of geological chronology, or in the fixing of systemic relationships, as the casual persistence of a few specific types, and, indeed, a paleontologist or zoologist would be very bold to assert that the distinctive characters of a fauna depend rather upon the features drawn from its specific than from its generic constituents.[*] It would appear strange, to say the least, if a geologist were now to unite the Devonian and Carboniferous formations, or the Silurian and Devonian, for no other reason than that they comprise in their several faunas a number of "common" forms, when the general facies of these faunas is very distinct.[†]

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* Published more than one year *after* the paper in the "Proceedings of the California Academy," and therefore at a time when Mr. Gabb ought to have been fully cognizant of the value and position of his intermediate beds.

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* The percentage takes into account the full number of forms said to be held in common by the upper member and the intermediate beds.

† The italics are Gabb's.

But it is here maintained, that in addition to a purely specific relationship we have one established through generic ties. "An Ammonite ranges entirely through the group to the top of the highest fossiliferous strata. The genera *Perissolax*, *Gyrodes*, *Margaritella*, and the sub-genus *Anchura*, of the genus *Aporrhais*, are all recognized as strictly characteristic of the Cretaceous; so much so, that the presence of a single undoubted representative of either of these genera would be strong presumptive evidence of the Cretaceous age of any rocks in which it might be found" (Proc. Cal. Acad., p. 306). Laying aside for the present the question of the Ammonite, only a few words need be said respecting the other genera.[‡] As Mr. Conrad has already shown (A. J. Science, new ser., xliv, p. 376), no locality in Division B is assigned to the (2) species of *Gyrodes* in vol. i of the report, but on the contrary, both are clearly assigned to the Division A; and in vol. ii (p 222) the transition beds are given as the upper limit of the genus. In the case of the genus (or sub-genus) *Anchura*, the species especially referred to, *A.* (*Aporrhais*) *angulata*, is stated (vol. i, p. 128) to occur very sparingly near Martiñez "in a single stratum of greenish-gray limestone," and is credited *exclusively* to Division B; yet, in the same description, a locality in Division A—Cottonwood Creek, Shasta County—is mentioned! Furthermore, in the "tabular statement" appended to the same volume (p 227), the Martiñez locality of the identical species is referred to Division A! In vol. ii (p. 226), while the localities are given, the group has been wisely omitted. As to the forms that have been referred to *Perissolax*, it would be very difficult to state why they should be considered as being characteristically Cretaceous. It is true that the genus was founded on Cretaceous species,[*] but it would be, indeed, a very comprehensive genus that would embrace such entirely dissimilar forms as the *Pyrula* (*Fusus*) *longirostra* of D'Orbigny,[†] one of the types of the genus, and the *P. Blakei* (*Busycon? Blakei* of Conrad) and *P. brevirostris* that are here referred to it (and also the *Fusus Durvillei* and *F. Hombroniana!*) [‡] There is, as far as we are aware, not the faintest reason for considering the California species here indicated as representing Cretaceous molluscan types, whatever may be thought of the genus *Perissolax* as originally founded; on the contrary, as Conrad has pointed out (A. J. Science, new ser., xliv, p. 376), they more properly belong to his genus *Levifusus* (sub-genus? of *Fusus*), represented in the Eocene of Alabama by the *Fusus trabeatus* (*F. bicarinatus* of Lea, young).

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[*] Accepting the generic determinations of Mr. Gabb, we find that of about 77 genera credited as belonging to the Tejon group, no less than 33 (or 43 per cent.) have *not* been described from the Cretaceous deposits underlying this group; and 3 additional ones do not pass beyond the "intermediate beds!" The faunas are here, then, decidedly *very* distinct, despite the fact that a limited number of "common" or passage forms (forming at the utmost only about 13 per cent. of the Tejon fauna) may be said to exist.

[†] According to Etheridge (Anniversary Address, London Geol. Soc., 1881—Quart. Journ. Geol. Soc., pp. 184–185), of 37 species of brachiopods occurring in the upper British Devonian, 16 pass into the succeeding Carboniferous deposits; these last also hold 5 species of upper Devonian lamellibranchs, 5 gasteropods, 2 heteropods, and 4 species of the genus *Orthoceras*. Of the total number of 183 genera and 526 species constituting the British Devonian fauna, 30 genera and 49 species pass into the Carboniferous (*loc. cit.*, p. 197). In California, of about 141 genera described from Division A (Martiñez, Chico, and Shasta groups), 44 are also found in Division B (Tejon group), and, therefore, the proportion of generic forms common to what is here claimed to be both Cretaceous and Tertiary is greater than that which obtains in the case of the British Devonian and Carboniferous formations. But if in both instances only the molluscan fauna (which comprises, with the exception of 5 species, all of Gabb's described forms) is taken into account, a very striking correspondence in the numerical proportions presents itself. Thus, according to Etheridge's tables, 25 out of the 74 Devonian molluscan genera appear in the Carboniferous deposits, or nearly 34 per cent.; in California, 40 of the 133 Division A genera are also represented in Division B, or 30 per cent. According to Mr. Etheridge (*loc. cit.*, p. 179), 12 genera (of 137), and 20 species (of 392), of Ludlow (upper Silurian) fossils pass into the Devonian; and 11 genera (of 61), and 16 species (of 182) from the Cambrian into the Silurian (Arenig) (p. 100).—The circumstance that the faunal break between the Cretaceous and Tertiary periods is in all, or nearly all, localities thus far studied greater than between the Devonian and Carboniferous or the Silurian and Devonian, has no bearing on the point at issue, since a connection or passage must exist somewhere, and it is quite immaterial where this passage may be found. The assertion that has at various times been repeated that no Cretaceous species have been known to pass beyond the limits of that period has been definitely refuted by comparisons made between the foraminiferal faunas of chalk and the Atlantic ooze, and, doubtless, impartial examination will reveal a number of higher forms in post-Cretaceous deposits, undistinguishable from forms which have up till now been considered to characterize strata of more ancient date. It would probably puzzle many paleontologists to determine by what special characters certain cephalopods (*Nautilus*) or brachiopods of Tertiary, or for that matter, of recent age, are distinguished from their more ancient congeners, and, indeed, even such a high authority as Mr. Davidson ("British Tertiary Brachiopoda," p. 14, Palæont. Soc. Repts., 1852), has found it difficult to differ from the opinion expressed by Edward Forbes that at least one existing brachiopod (*Terebratulina caput serpentis*) is also a Cretaceous form.

[‡] Although in the text it is not *absolutely* stated that these several genera all occur in the rocks of the Tejon group (but "in this and associated rocks"), the connection in which the statement is made would seem to imply that they did so occur; and Mr. Gabb's inference would certainly justify such an interpretation of the statement.

Respecting the forms that have been referred to *Margaritella*, and to their being "strictly characteristic of the Cretaceous," it need only be stated that Mr. Meek, the author of the aforesaid genus, distinctly affirms [§] that they do *not* belong where they have been placed, but in the genus *Solariella* of Wood, which was founded on a Tertiary (Pliocene) fossil, *S.* (*Margarita?*) *maculata* from the British Coralline Crag.[‖]

So far, therefore, not one of Gabb's characteristic Cretaceous genera, with the exception of the Ammonite, of which several specimens are said to have been found in the rocks of the Tejon group (and of which, or of an allied genus of the *Ammonitidæ*,[¶] the author of this article was fortunate enough to discover a solitary fragment), carries out the inference that has been drawn from their actual or supposed existence.

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[*] Gabb, Proc. Am. Philos. Soc., 1861, p. 66.

[†] *Paléont. de l'Amér. mér.*, p. 119, pl. 12, fig. 13.

[‡] D'Orbigny, *Voyage de l'Astrolabe et de la Zélée*, pl. 2, fig. 1, and pl. 1, fig. 31. . . . Gabb, Proc. Amer. Philos. Soc. 1861, p. 67. It can scarcely be wondered at that neither Conrad nor Stoliczka could grasp the characters of the genus, and that the latter referred the typical form not only to a distinct genus, but to a very different family, the *Purpuridæ* (Palæontologia Indica, Cretaceous Fauna, ii, p. 149).

[§] U. S. Geol. Survey of the Territories, ix, Invertebrate Palæontology, pp. 301–2, 1876.

[‖] Catalogue of Crag Mollusca, Ann. Mag. Nat. Hist., ix, 1842, p. 531; "British Crag Mollusca" (Palæont. Soc. Rep., 1848), i, p. 134.

[¶] The fragment was too imperfect to admit of positive generic determination.

Having thus, as we believe, satisfactorily shown the erroneousness of many or most of the data that have served as a guide in the classification of the rocks in question, and to their reference to the Cretaceous period, it now remains to examine in greater detail the reasons why these should be considered as *not* Cretaceous, but Tertiary. Briefly repeating what has already been said, we find that the Tejon fauna (considered solely with respect to the other California faunas) comprises about (and *probably considerably more than*) 80 per cent. of forms peculiar to itself, or at least that are not found in deposits representing a lower horizon; that 33 out of its 77 genera, constituting 43 per cent. of its entire number, are likewise not represented in the older deposits; that with the exception of a few fragments or specimens (about 7 in all) of one or two forms of *Ammonitidæ*, there is a complete absence of distinctively Cretaceous organic types (while they are sufficiently plentiful in the subjacent beds); and finally, that there is a sudden introduction of new molluscan types, most of which are but barely, if at all, represented in the Cretaceous desposits of the world (as far as has yet been determined), and several of which are not known to have preceded the Tertiary period. The appearance here for the first time of the genera *Ancillaria*, *Bulla*, *Conus*, *Crepidula Cassidaria*, *Cypræa*, *Ficus*, *Gadus*, *Mitra*, *Nassa*, *Niso*, *Olivella* (or *Oliva*), *Pseudoliva*, *Rimella*, *Triton*, *Trochita*, and *Typhis** has already been adverted to.

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* The writer is unaware that any unequivocal species of the genera ***Ficus*** (*Sycotypus*; *Pyrula*, as restricted) ***Gadus***, ***Nassa***, ***Niso***, ***Olivella*** (or ***Oliva***), ***Rimella***, or ***Typhis***, have been described from deposits antedating the Tertiary.

Pyrula Pondicherriensis of Forbes (Trans. Lond. Geol. Soc., vii, p. 127, 1846; *Pyrula Carolina* of d'Orbigny, Voy. Astrolabe et Zélée, Pal. pl. 11, figs. 34 and 35), a ficuliform species from the Cretaceous deposits of India, has been shown by Stoliczka to belong to the *Volutidæ*, and to a new genus, ***Ficulopsis*** (Pal. Indica, Cretac. Fauna, ii, pp. 84–5).

Nassa lineata of Sowerby (Fitton's Report, Trans. Lond. Geol. Soc., 2d ser., iv, p. 344, pl. xviii, p. 25), from the Blackdown sands, may be a true member of the genus to which it is referred, but neither the figure nor description of the species permits of such a determination. The second species described in the same report, *N. costellata*, has been referred by d'Orbigny, Pictet, and Stoliczka to *Cerithium*. The first of these is the only Cretaceous species recognized by Pictet and Campiche (*Matériaux p. l. Paléont. Suisse*, iii ser., p. 673) as being probably a *Nassa*, but the author's conclusions on this point appear to have been based entirely upon Sowerby's original determination. Stoliczka (*op. cit*, p. 143) places *Buccinum Steiningeri* of Müller (*Petr. Aach. Kreidef.*, p. 78, 1851), an unfigured species from the chalk of Aix-la-Chapelle, in *Nassa*, but on what authority, or for what reasons, this reference is made, we have found it impossible to discover. The two species of *Nassa* described by the last-named author from the Cretaceous Arrialoor group of India, *N. Vylapaudensis* and *N. Arrialoorensis*, and determined from imperfect specimens, are at best but very doubtful, and, indeed, it is stated that the last may possibly be a *Mangelia* or *Defrancia* (*op. cit.*, p. 145)!

Niso Nerea of Deslongchamps (*Bull. Soc. Linn. Norm.*, 1860, v, p. 126; *Turbo Nerea* of d'Orbigny, *Pal. Franc. Terr. Jur.*, pl. cccxxvi, figs. 4 and 5), considered by Stoliczka (*op. cit.*, p. 288) to be possibly referable to one of the subgenera of *Niso*, does not appear to have much, if anything, in common with that genus; nor can much more be said in favor of the other species (*Turbo*, *Trochus*, etc.) referred by Deslongchamps to the same genus.

Oliva vetusta of Forbes (Trans. Lond. Geol. Soc., 2d ser., vii, p. 134, pl. 12, fig. 23), from the Cretaceous rocks of Southern India, is a *Dipsacus* according to Stoliczka (Pal. Indica, Cret. Fauna, ii, p. 452, pl. xxviii, fig. 27). The *Oliva? prisca* of Binkhorst (*Monogr. Gastr. et Ceph. Craie sup. de Limbourg*, 1861, p. 71, pl. Va', fig. 14) is unrecognizable as a member of the genus to which it is referred, and, according to the author himself, may possibly be a fragment of a *Cypræa*.

Of the genera *Pseudoliva* and *Ancillaria* it would appear that only a single Cretaceous species of each has thus far been recognized: the *P. subcostata* of Stoliczka (*op. cit.*, p. 145) (from the Arrialoor group of Southern

But these are not the only more or less strictly Tertiary genera that are here represented. In the *Tritonium paucivaricatum* (Palæont. Calif., i, p. 95, figs. 209, 209 *a*, very badly figured) we have a true *Cancellaria!* The *Megistostoma* (new genus[*]) *striata* (i, p. 144) is a true *Bullæa*, a genus represented by a very limited number of fossil forms, and so far not known to have appeared before the Tertiary period. *Naticina obliqua* (i, p. 109) appears more like a *Sigaretus*, the shell (in the specimens examined, all of which are partially imbedded in the matrix) being considerably more impressed than in the genus *Naticina*. But to whichever of these two genera the species may belong, it is immaterial in the present consideration, since no unequivocal member of either form, as far as the writer is aware, has been described from any formation older than the Tertiary.[†] In vol. ii of the Report (p. 157) we have described a member of the genus *Bullia* (sub-genus *Molopophorus*, doubtfully different from the Tertiary and recent genus, or sub-genus, *Buccinanops*); and finally (*Ibid.*, p. 162), a *Terebra* (*T. Californica*), a genus whose range has not yet positively been determined to extend back beyond the limits of the Tertiary period.

So that of the 77 genera represented in the Tejon group, at the very least 22 are more or less distinctively[‡] Tertiary; and of these 22, 11 are not positively known to have appeared before that epoch of geological time. On the other hand, if we except the six or seven fragments of *Ammonitidæ* (one, or possibly two genera) already referred to, there would seem to be in the entire number *not a single distinctively Cretaceous generic type!*

Evidence afforded by Specific Forms.

The circumstance, considering the deposits here referred to to be Eocene, that "not one [species] has been found associated either with living forms, or with species known to occur in the recognized Tertiaries [Miocene and Pliocene] of California"

India), described from a solitary imperfect specimen, and the *A. cretacea* of Müller (*Monogr. Petr. Aach. Kreidef.* p. 79, pl. 6, fig. 23), from the chalk of Aix-la-Chapelle, and described from a single imperfect impression. The least equivocal of the several doubtful Cretaceous forms that have been referred to the genus *Conus* is probably the *C. Marticensis* of Matheron (*Cat. des Corps organisés fossiles, Bouches-du-Rhone*, 1842, p. 257, pl. 40, figs. 24–25), from the chalk of Martigues. There seems to be no reason for specially doubting that the imperfect specimen here figured is a true cone, but yet it would be by no means surprising if closer examination would prove it to be a form more closely related to *Acteonella* or *Acteonina*. The *C. tuberculatus* of Dujardin (*Mém. Soc. Géol. de France*, 1835, ii, p. 232, pl. xvii, fig. 11), from the chalk of Tours, is not unlikely, according to Stoliczka (*op. cit.*, p. 72), to be a member of the Cretaceous genus *Gosavia*, which it resembles (differing from all other true cones) in its ornamentation. *Conus canalis* of Conrad (Journ. Acad. Nat. Sciences Phila., 2d ser., iii, p. 321, pl. 35, fig. 22), from the "Ripley" group of Mississippi, scarcely admits of positive generic determination. *Conus gyratus* of Morton, (Syn. Org. Remains, Cretac. group, 1834, p. 49, pl. x, fig. 13), from the white limestone of South Carolina, is an Eocene species.

[*] The distinctive characters of this supposed new genus, as pointed out by Gabb, are more imaginary than real.

[†] *Natica acutimargo* of Rœmer (*Verst. Nordd. Kreidgeb.* 1841, p. 83, pl. xii, figs. 14, *a*, *b*), from the chalk marl of Quedlinburg and Dülmen, and said to have fine revolving lines, may possibly prove to be a *Sigaretus*, but the sutural canaliculation would seem to render this point rather suspicious. *Sigaretus Pidanceti* of Coquand (*Mém. de la Soc. d'émul. du Doubs*, 2me sér., vii, p. 46, pl. 5, figs. 4 and 5, 1856) is a *Natica* according to Pictet and Campiche (*Mat. Paléont. Suisse*, 3me sér., p. 180, pl. lxxvi, figs. 1, *a*, *b*, *c*).

[‡] But sparsely, if at all, indicated in the earlier deposits.

(Gabb, Proc. Calif. Acad. Nat. Sciences, 1867, p. 306), is not very surprising. The number of species that pass from the deposits of Eocene age into the Miocene is frequently very limited, or there may not be a single one. This last is, singularly enough, what obtains in the case of the Tertiaries of the eastern and southern United States, where both the Eocene and Miocene formations are extensively developed, and where the organic remains are also very abundant.*

Leaving aside the question of identity as existing between the Eocene and Miocene forms, it will be important to ascertain what correspondence, if any, manifests itself between the specific types of the deposits here discussed, and those of other Tertiary (Eocene) localities; for the determination of this point we subjoin the following notes on a few of the species:

CARDITA HORNII AND CARDITA PLANICOSTA.—Whether the species of *Cardita* described by Conrad from the rock of Cañada de las Uvas as *C. planicosta* (Pacific R. R. Reports, v, p. 321), and designated by him as the "finger post of the Eocene" (*Ibid.*, p. 318), is the veritable *C. planicosta* of Lamarck, or not, it is impossible to state. The author's intimate acquaintance with that species, from both European and American forms, ought certainly to have enabled him, in the presence of fairly preserved specimens, to determine this point definitely, but whether the specimens in question were actually in a condition to admit of such positive determination, can, at the present time, only be conjectured. The description accords well with the species (and in a measure, also, the figure), but it is a little too brief to admit of a positive conclusion being drawn therefrom. For a similar reason it would be impossible to affirm conclusively whether the species is, or is not, the *C. Hornii* of Gabb (Palæont. Calif., i, p. 174; ii, p. 188), specimens of which were found near the same locality. I believe there can be no doubt that the character pointed out by Gabb (ii, p. 188), as distinguishing the two species here mentioned—namely, the form of the ribs, which are rounded in the one (*C. Hornii*), and flattened in the other (*C. planicosta*)—has a certain value, but whether sufficient to permit of specific distinctions being based upon it in the absence of all other characters, can only be determined when a greater number of perfect specimens will have been brought together for comparison. In all other respects the two species appear to be identical, as will be seen from the following (Gabb's) statement: "I have compared my specimens with shells from the London clay, and from the Alabama Eocene, and find that, except in the extreme quadrate forms,† they are absolutely identical in all characters save one. The hinges are so similar that I despair of making an intelligible written description of their minute differences, and should hardly feel willing to trust an artist with their delineation." Granting the specific value of the character claimed by the aforesaid paleontologist, the type (*C. Hornii*) still remains distinctively Tertiary,‡ since what may be considered as analogous forms, are to the knowledge of the writer, completely wanting (although the genus is already represented) in the pre-Tertiary deposits.

DOSINIA ELEVATA (i, p. 167) is more likely, as stated by Conrad, to be a *Dosiniopsis* than *Dosinia* (Am. J. Conchol., ii, p. 98), despite the assurances of Mr. Gabb to the contrary (*Ibid.*,

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* It would be, perhaps, going too far to state, that not a single species is held in common by these Eocene and Miocene deposits; it would be more proper to say, that none such has yet been recognized.

† . . . though some specimens, four and four and a half inches across, are as distinctly triangular as the typical *planicosta*" (ii, p. 188).

‡ The character of the ribs, previous to weathering, is very much as in the *C. pectuncularis* or the *C. Jouanneti.*

p. 91).[*] As much as can be determined from the figured specimen it appears to be very closely allied to the *Dosiniopsis Meekii* of Conrad (*Cytherea lenticularis?* of Rogers), from the lower Eocene of Maryland and Virginia, from which it mainly (or barely) differs in the greater width of the flattened area on the posterior slope.

MERETRIX HORNII (i, p. 64 ; ii, pl. 30, fig. 78), a form allied to, but not as produced posteriorly as the *Cytherea suberycinoides* of the Paris basins.

FICOPSIS (HEMIFUSUS) RÉMONDII (i, p. 87, pl. 18, fig. 36), a form very closely related to, if not identical with the *Pyrula penita* of Conrad (= *P. nexilis* and *P. tricarinata* of Lamarck), from the Eocene of Claiborne, Ala. The occasional tricarination observable in that form, as well as in its European representative, is here also apparent. The only difference of any account I could detect between the two species is that in the Californian form the surface reticulation is somewhat the finer, but since there is no exact constancy in the order of this reticulation, it may be doubted whether the difference here noted is of more than varietal value.

TRITONIUM PAUCIVARICATUM (i, p. 95, pl. 28, figs. 209, 209*a*, unrecognizably figured), as has already been stated, is a *Cancellaria*, and a form so closely related to the *C. evulsa*[†] of Brander ("Fossilia Hantoniensia," 1766, p. 14, as *Buccinum;* pl. 1, fig. 14), from the British Bartonian (Upper Eocene), that it may well be doubted whether it is at all specifically distinct; and the same may be said of its relation to a form[‡] from the Lower Eocene deposits of Clarke County, Ala., which is doubtfully referable to the *C. tortiplica* of Conrad.

MEGISTOSTOMA STRIATA (i, p. 144, pl. 21, fig. 108*a*, *b*).—While, perhaps, from the slightly imperfect condition of the specimen, it would be impossible to affirm positively that this species is identical with the *Bullæa expansa* of Dixon, from the Eocene of Brackelsham, England, and the Paris basin (Deshayes, *Animaux sans Vertèbres, Bassin de Paris*, ii, p. 652, pl. 36, figs. 27–30), yet, what there is of it shows absolutely no character by which to distinguish it from that species.

Conclusion.

We believe it has been satisfactorily shown, from what has preceded, that the rocks of the Tejon group (Cretaceous Div. B. of the California survey), despite their comprising in their contained faunas a limited number of forms[§] from the subjacent

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[*] No perfect hinge is exhibited in any of the specimens of the Gabb collection, which includes the figured form.

[†] Compared with actual specimens.

[‡] Kindly transmitted for examination, with other fossils, by Dr. Eugene A. Smith, State Geologist of Alabama.

[§] The reliance that is to be placed upon Gabb's *positive* assertions as to the localities or horizons whence certain species have been obtained, may be inferred from the statement (Am. Journ. Conchology, 1866, ii, p. 90), that *Naticina obliqua* and *Turritella Uvasana*, species claimed to be Eocene by Conrad, were "found by Mr. Rémond and myself in strata containing *Ammonites* and *Baculites*, and abounding in other Cretaceous forms." A reference to the descriptions of these two species, as well as to the various tables of distribution published (before and after the making of the statement) by Gabb, clearly shows that the forms in question were *not* known to that paleontologist to pass beyond the limits of Division B. How then could they be associated with the *Baculites*, when the only Californian species of that genus, *B. Chicoensis*, is distinctly stated (i, p. 81) to be "only found in Div. A"? So likewise from the statement (Am. Journ. Conchology, ii, p. 89), that *? Ammonites Cooperii*, "one of the *Ammonitidæ*, whether an *Ammonite* or not, is from the presumed Eocene of Mr. Conrad, from San Diego, and the family is sufficient to establish the age of that deposit, had we no other proof." But singularly enough, in the description of this ammonitic fragment (i, p. 70), the specimen is said to be "of particular interest from the fact that it is *one of the oldest* fossils found in the southern part of the State, being *considerably below* the newer Cretaceous fossils of San Diego!" (The italics belong to the writer of this article.) And in vol. ii (p. 212), the species is doubtfully referred to the Chico group!

(Cretaceous) deposits, and a few undoubted representatives of the *Ammonitidæ*, are of Tertiary (Eocene) age, and for the following reasons:—

I. The large percentage (about 80, or possibly considerable more) of specific forms that are peculiar to the group, or, at least, are not found in the older deposits;

II. The large proportion of generic forms (33 out of 77) that are not represented in the underlying or older strata;

III. The presence of 22 more or less distinctively Tertiary genera: *Ancillaria*, *Bulla*, *Bullæa* (*Megistostoma*), *Bullia* (s. g. *Molopophorus*), *Conus*, *Crepidula*, *Cassidaria*, *Cancellaria*, *Cypræa*, *Ficus* (*Ficopsis*), *Gadus*, *Mitra*, *Nassa*, *Niso*, *Olivella* (or *Oliva*) *Pseudoliva*, *Rimella*, *Sigaretus* (or *Naticina*), *Terebra*, *Triton*, *Trochita*, and *Typhis*;

IV. The marked absence (with the exception of about a half a dozen fragments or specimens of *Ammonitidæ*) of distinctively Cretaceous organic types;

V. The identity, or very close analogy, existing between several of the specific forms and their representatives from other well-determined Tertiary (Eocene) deposits.*

NOTE.—Since the printing of the above I have been furnished, through the kindness of Dr. C. A. White, Paleontologist to the U. S. Geological Survey, with further corroborative, and indisputable, evidence bearing upon the Tertiary age of the Tejon rocks. Dr. White, who, in the interests of the Geological Survey, made a personal examination of the region during several months of the present year, and who has just completed his exploration, advises me, under date of October 16th, Washington, D. C., that he " found the Chico and Tejon forming one continuous and unbroken series. I throw out of consideration Gabb's so called Martinez Group and intermediate beds. The Chico-Tejon series I found in Fresno County to be at least 10,000 feet in vertical thickness. The series has every appearance of having been formed by continuous and unbroken sedimentation; and there is a gradual faunal change from real, but late, Cretaceous to unquestionable Eocene. I am sure that the Cretaceous and Eocene types are commingled in this series, but toward the base the fauna is more clearly

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* The Eocene age of the Tejon rocks is maintained by Prof. Jules Marcou (Report of the Chief of Engineers, Washington, 1876, p. 387), who made a personal examination of the region. "I was not able to find a single Cretaceous fossil, nor even any true Cretaceous generic forms, in the entire formation; and I am altogether of the opinion expressed by Mr. Conrad, many years before Mr. Gabb, in volume 5, of Pacific Railroad Explorations, pages 318, 320, *et seq.*, who, judging from certain fossils found in an isolated block, at the entrance of the Cañada de las Uvas, has very judiciously referred these rocks to the Eocene-Tertiary formation" . . . "The fauna of Tejon reminds one very much of the fauna of the sands of Anvers [?], near Pontoise, and of the sands of Gre[*i*, ?]gnon, near Versailles."

Cretaceous, and toward the top it appears to have lost all Cretaceous character. Some of the species, however, appear to range nearly, perhaps quite, through the series."

The full results of Dr. White's exploration will shortly be published in the "Bulletin" of the U. S. Geological Survey.

CORRECTION.

The following species, omitted from pages 48 and 49, should be included in the Maryland Miocene fauna as a part of the "98:"

Anomia ephippium, . . .	("Newer" Group).
Arca stilicidium, . . .	" "
? Artemis concentrica, . . .	" "
Astarte planulata (= A. perplana?)	" "
Mactra incrassata, . . .	" "
Ostrea percrassa, . . .	("Older" Group).

Anomia ephippium is still living.

The slight alterations resulting from this addition do not sensibly affect the question involved.

⁂ The broken lines in the "Jacksonian" and "Virginian" on the map indicate hypothetical areas; where continuously lined, the areas have been determined by field observation.

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